

Transmissions
Elektronen Mikroskop

Transmission
Electron Microscope

EM 900

Gebrauchsanleitung

Operating Instructions

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Electron Microscope

EM 900

Chapter

- 1.0 Specifications
- 2.0 Installation, supply, accessories
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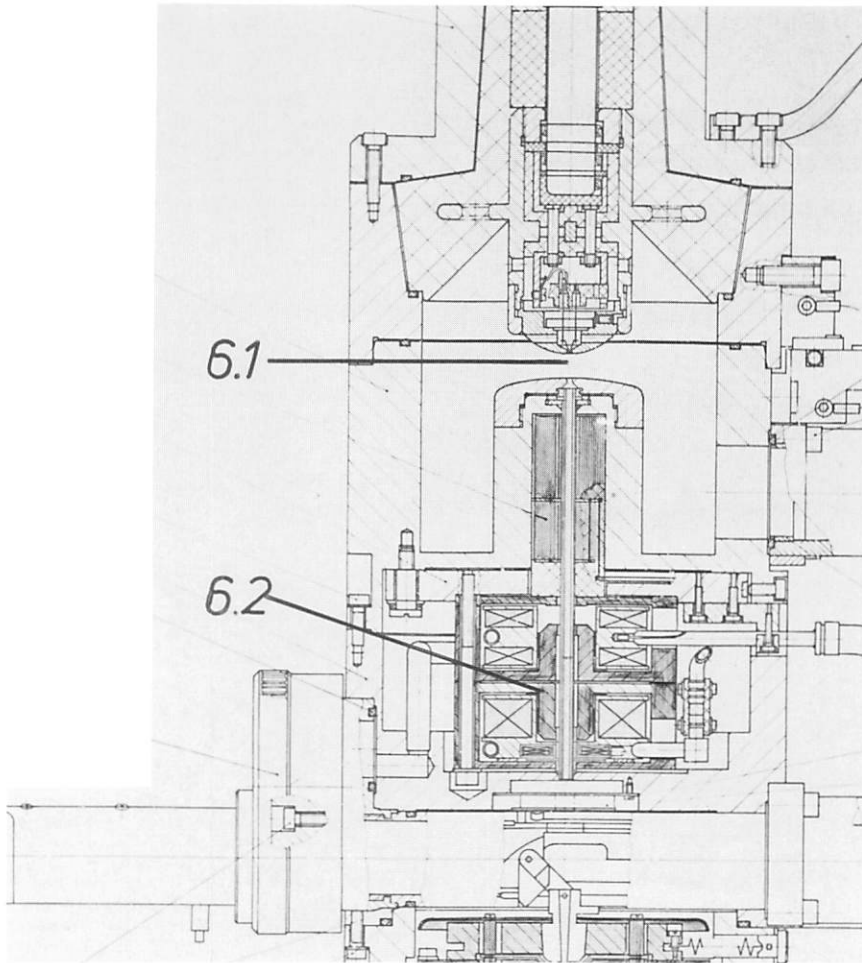
Carl Zeiss
Postfach 13 69/80
D-7082 Oberkochen
West Germany

G 34-616-e

EM 900
Transmission Electron Microscope

Specifications of base instrument

- Chapter 1: Column
Factory-aligned
Vibration-resistant mounting
- Chapter 2: Resolution (80kV)
Guaranteed lattice resolution: 0.344nm
Guaranteed point resolution: 0.5nm
- Chapter 3: Accelerating voltage
50kV, 80kV
Stability at 80kV: 8×10^{-6}
- Chapter 4: Magnification
HC mode:
Steps 1-5, Low Mag 165, 275, 440, 770, 1,210x
Steps 6-15, 1,200, 1,760, 2,800, 4,800, 8,000,
12,000, 20,000, 34,000, 56,000, 100,000x.
Focus maintained in the range from 100,000x to
1,200x during change of magnification.
HR mode:
Steps 1-5, Low Mag 150, 250, 400, 700, 1,100x
Steps 6-15, 3,000, 4,400, 7,000, 12,000, 20,000,
30,000, 50,000, 85,000, 140,000, 250,000x.
Focus maintained in the range from 250,000x to
3,000x during change of magnification.
HM mode:
400,000x
(Widefield, high-contrast imaging from 150x to
1,100x or from 165x to 1,210x. Zeiss patent: BRD DE
27 42 264 C3 and USA 4,194,116);
Digital display of magnification by 6 LEDs.

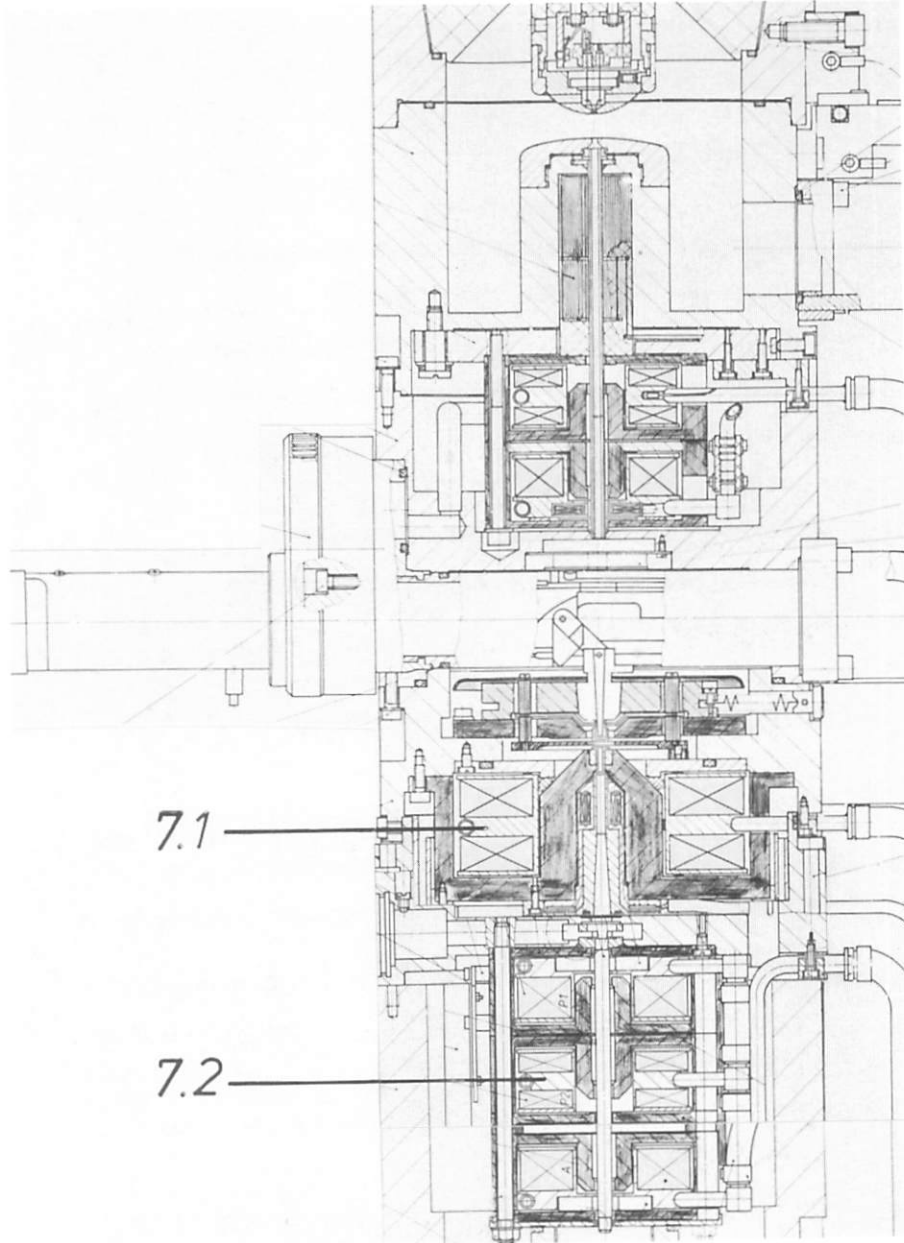


Chapter 5: Electron diffraction

Switch for easy change to diffraction mode
5 diffraction lengths from 390mm to 2,900mm
Diffraction range: 1.5 μ m dia. (Selected Area
Diffraction)
3 μ m dia. (Micro-beam diffraction)

Chapter 6: Illuminating system

- 6.1 Electron gun: high-voltage bushing with optimized insulator (Zeiss patent USA 4,396,861);
Pre-centered tungsten hairpin or pointed filament;
Beam current variable in 5 steps: 1 to 50 μ A (80kV) or 1 to 100 μ A (50kV);
Analog display of beam current;
Beam alignment by electromagnetic system;
Adjusting aid for quick beam location (e.g. after filament exchange)
- 6.2 Double condenser system factory-aligned;
Stability of lens currents 6×10^{-6} ;
Specimen illumination variable from 3 μ m to 2mm dia.;
Electromagnetic stigmator in condenser 2;
3 exchangeable and centrable molybdenum condenser apertures (100, 200 and 400 μ m dia.)



Chapter 7: Imaging system

7.1 Objective lens: factory-aligned high-performance objective lens; focal lengths 2.6mm in HR mode and 6.25mm in HC mode

	HR mode	HC mode
Focal length	2.6mm	6.25mm
Spherical aberration constant	2.2mm	13.5mm
Chromatic aberration constant	1.7mm	5.1mm
Basic astigmatism	< 1 μ m	
Guaranteed line resolution	0.34nm	0.9nm
Stability of lens current	4x10 ⁻⁶	

Drift of lens current: 2x10⁻⁶/min

Digital focusing by a single knob with automatic matching of the focusing steps to magnification and accelerating voltage;

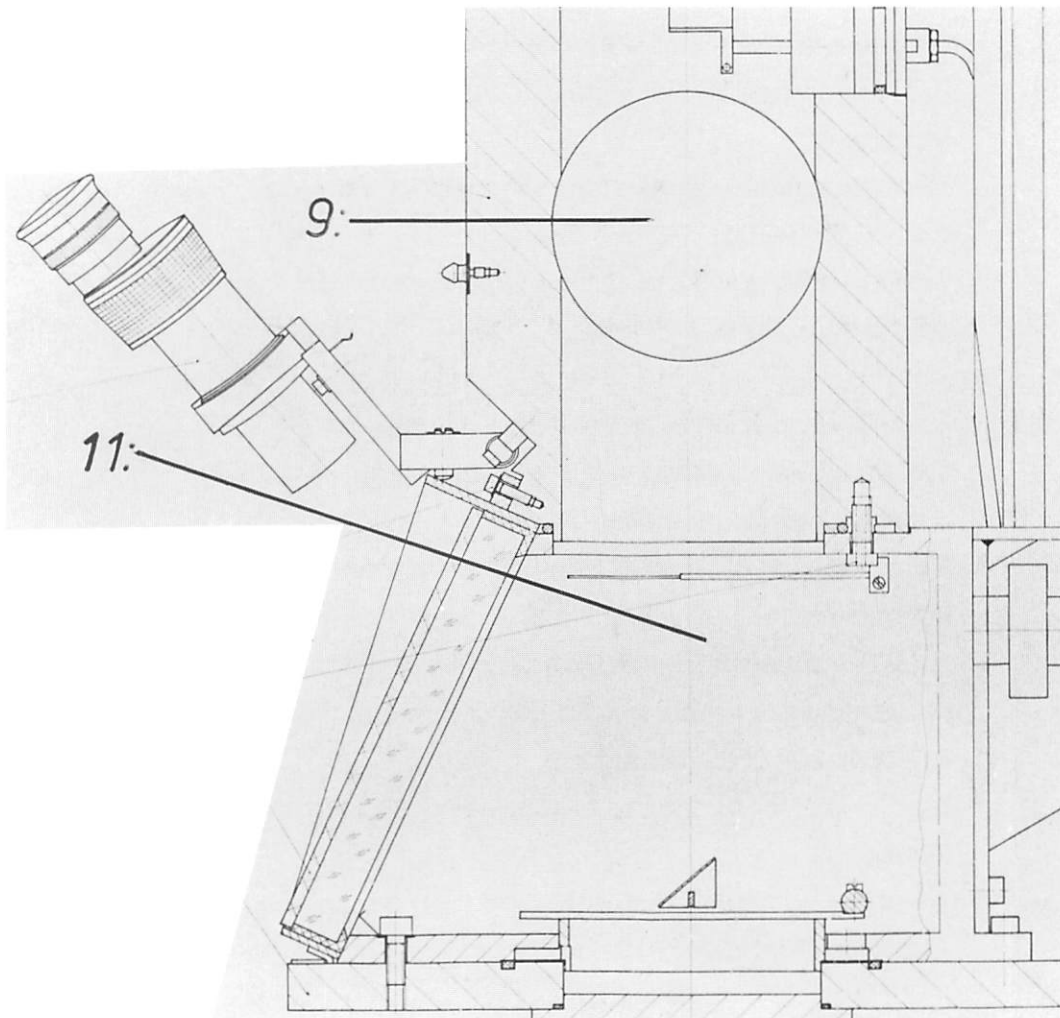
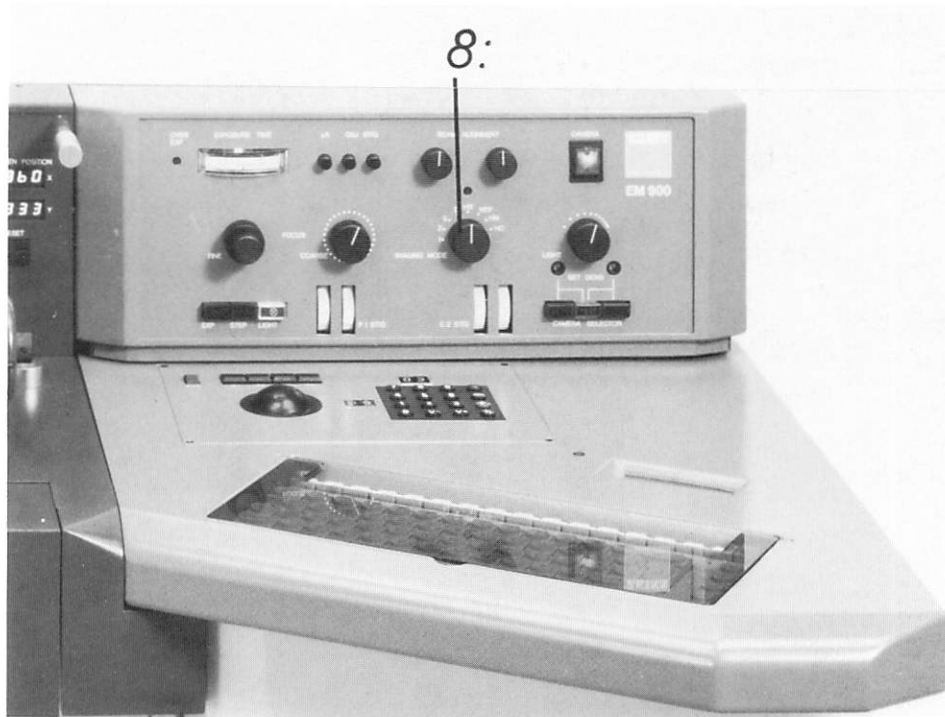
Minimum focusing step 15nm (at 140,000x);

Pushbutton-operated change of focusing step by a factor of 4;

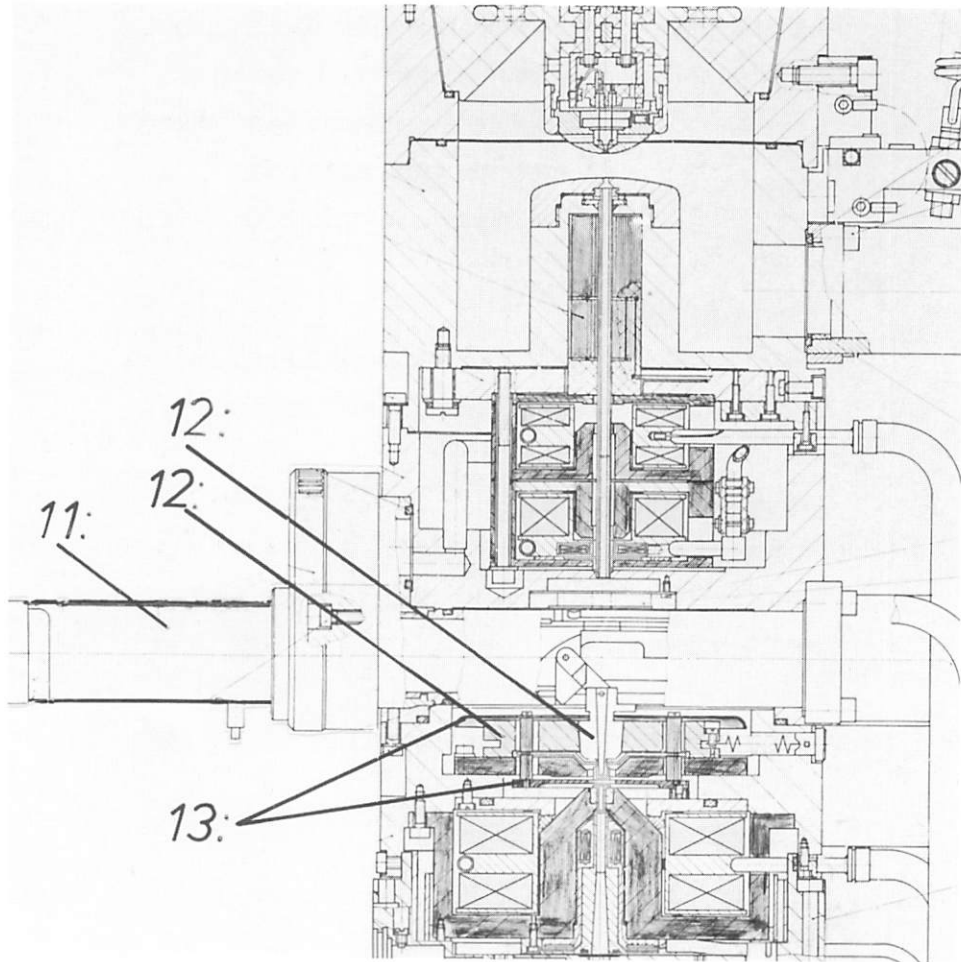
Electromagnetic objective lens stigmator with analog display of setting;

Three thin-film apertures: 180 μ m, 90 μ m, and seven-hole aperture (3x60 μ m, 4x30 μ m)

7.2 Projector lens system: factory-aligned three-lens system with electromagnetic stigmator in projector lens 1; Stability of lens currents 6x10⁻⁶;
 Compensation of chromatic and spherical aberrations up to $E/E = 10^{-3}$;
 Fix-focus connection (with SA mode) in the magnification range from 1,200x to 100,000x (HC mode) or from 3,000x to 250,000x (HR mode);
 Max. shift of focus referred to specimen < 100nm (in HR mode);
 Three exchangeable and centrable molybdenum selector apertures (50, 200 and 400 μ m dia.)



- Chapter 8: Imaging mode selector
Positions 1, 2, 3: alignment and test programs
Position D: diffraction
Position HC: high-contrast imaging
Position HR: high-resolution imaging
Position HM: high-magnification (400,000x)
imaging
Position MDF: micro/minimum dose focusing for
specimen protection; focusing at
140,000x magnification $5\mu\text{m}$ adjacent
to specimen area selected for
photography
- Chapter 9: Intermediate tube
with electromagnetic shutter and ports for accessories
(e.g. TV/CCD camera systems, 35mm camera)
- Chapter 10: Viewing chamber
Fluorescent screen, 140mm dia.
Focusing fluorescent screen, 70x30mm, swung in
independently;
Viewing window 220x127mm;
Swing-up binocular viewing microscope 9x, movable
horizontally through 50mm;
Central beam stop for diffraction



Chapter 11: Specimen airlock

Top-entry eccentric airlock system with automatic ventilation of airlock chamber, electronic ready display, lock-in time approx. 5s

Chapter 12: Specimen cartridges

for HR and HC modes and 3mm dia. specimen grids;
other specimen manipulation cartridges optional

Specimen stage

2mm travelling range in X and Y by manual drives or
2mm electronic stage shift in X and Y with digital
display of X,Y position accurate to $1\mu\text{m}$;

Storage and automatic re-location of max. 100

X,Y positions;

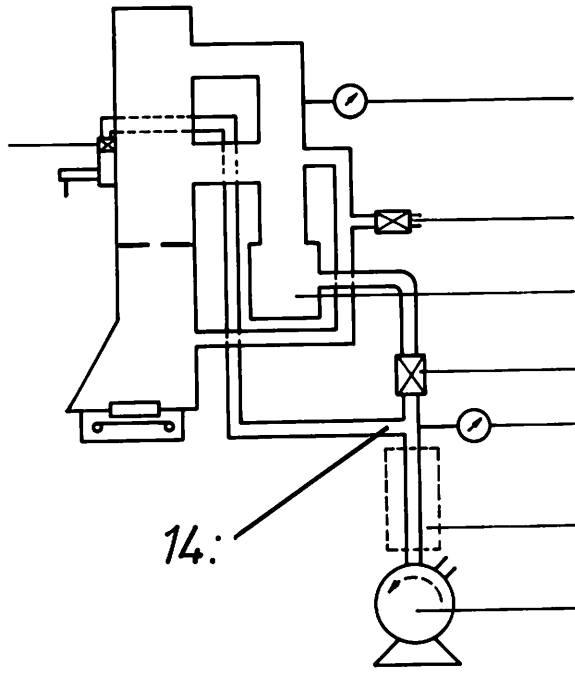
Re-location accuracy of stored specimen spots $< 1\mu\text{m}$

Chapter 13: Anticontaminator

3 cooling plates with an overall surface of $> 400\text{cm}^2$;

Temperature of cooling plates -165°C (approx. 100K);

Standing time with filled 1-l Dewar vessel: 5-7hrs.



Chapter 14: Vacuum system

Differential vacuum system with turbomolecular pump (170l/s suction capacity) and two-stage rotary pump (8m³/h suction capacity);

Automatic, microprocessor-controlled pump electronics;

System ready approx. 5min. after switch-on (nitrogen ventilation necessary);

Coded, digital status displays to monitor the vacuum system;

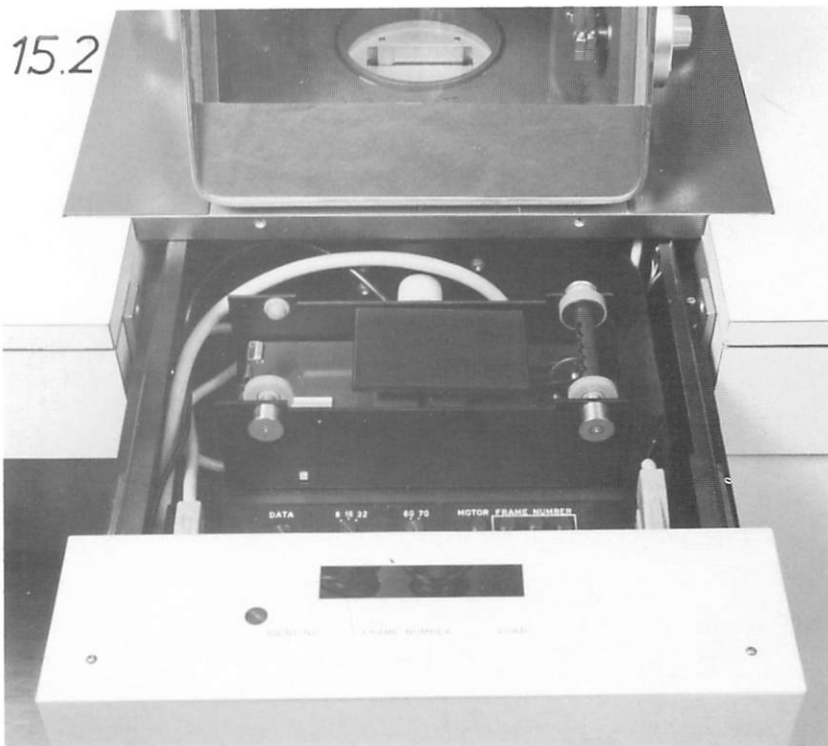
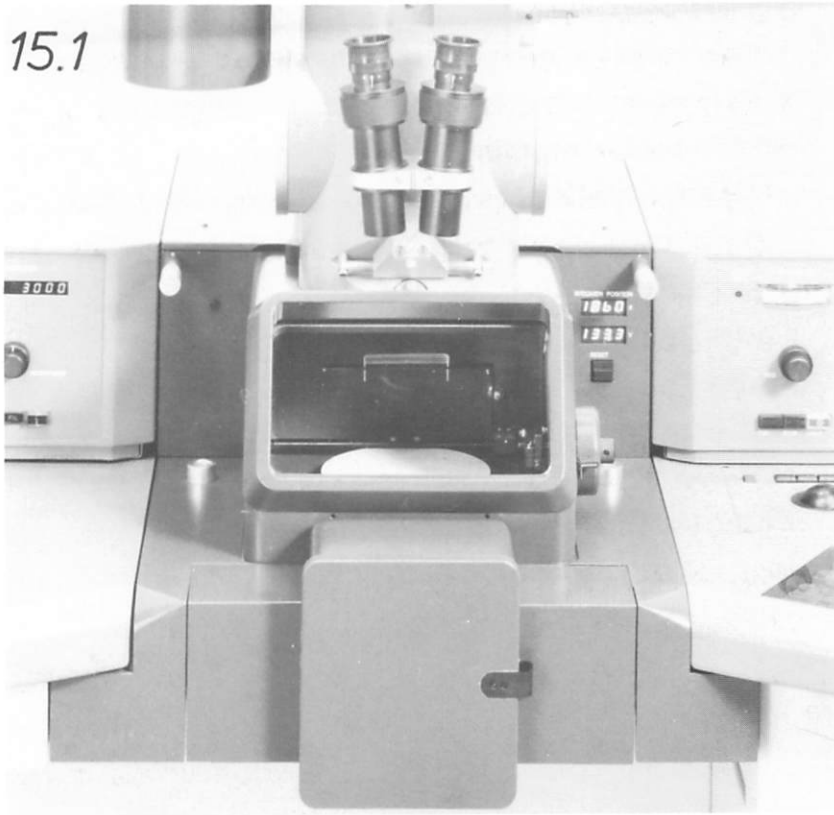
High-vacuum measurement: Penning system

High-vacuum digital display from 1x10⁻³ to 1x10⁻⁷hPa*

Guaranteed high vacuum: 2x10⁻⁶hPa*

High-voltage go-ahead: < 2x10⁻⁴hPa*

*1hPa = 1mbar



Chapter 15: Photography systems

All camera systems with automatic exposure control by measuring the electron density on the focusing fluorescent screen (sheet film camera: measurement on the focusing fluorescent screen or a measuring plate of the camera) and analog display of exposure times from 0.5s to 50s, with overload warning light (sheet film camera: digital display of exposure times from 0.2s to 100s);
Ready display;
Data and negative densities separately adjustable

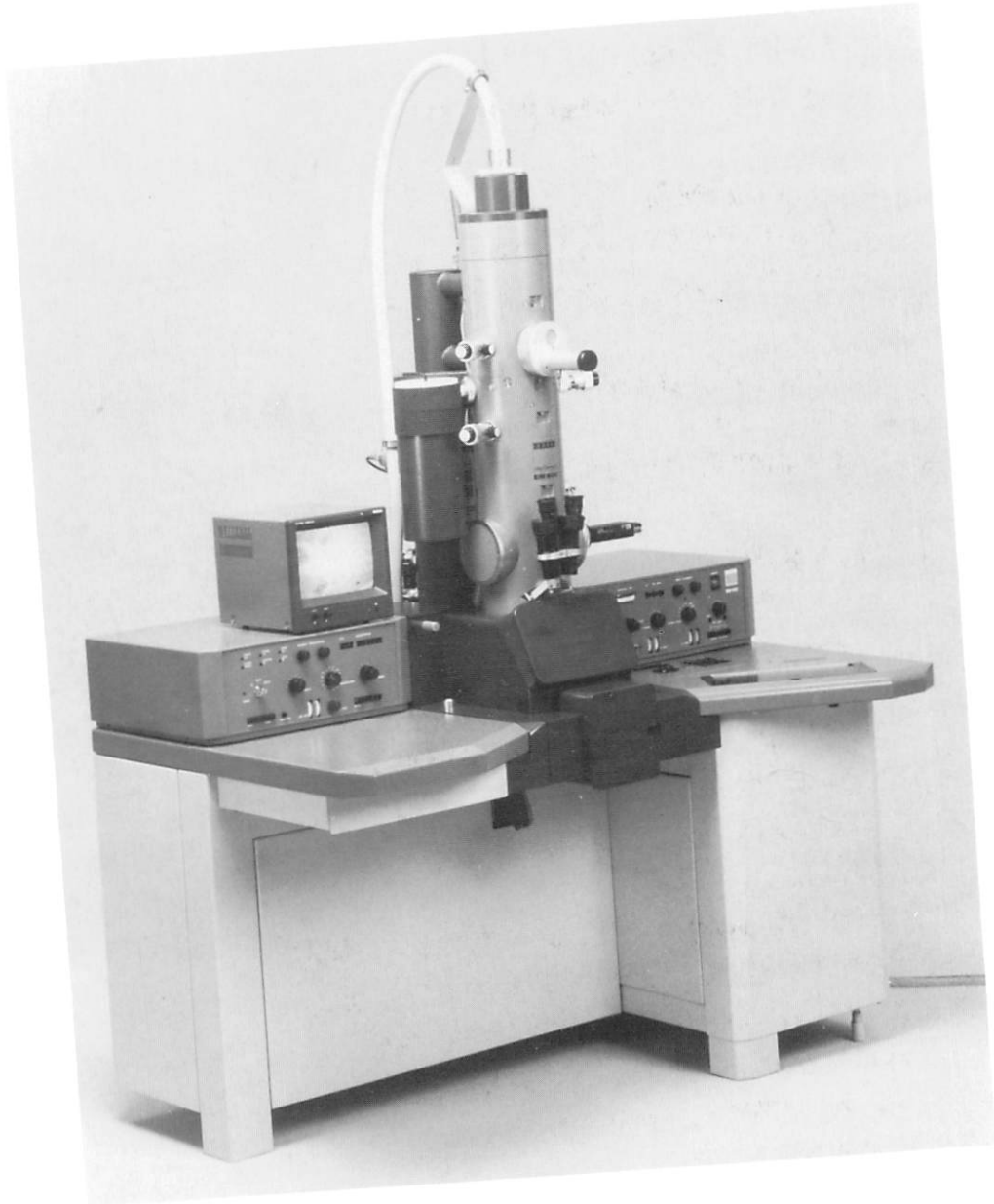
15.1

Sheet film camera microprocessor-controlled;
Film format: 3¼"x4" or 6.5x9cm (optional);
Picture size: 78x78mm or 65x70mm;
Capacity: 40 sheet film or 20 universal film holders;
Documentation data on the negative: automatic imprint of magnification, scale bar with length, high voltage;
Input from keyboard with LCD of 30 alphanumeric characters (2 letter fields + 6 number fields + 22 alphanumeric fields);
Activation of camera parameters such as unexposed film, data density or image density by function keys on the keyboard;
Option: RS 232 interface for remote control of sheet film camera

8.4025.H.

1.0 EM 900 specifications

Chapter		Page
1	Column	1.1
2	Resolution	1.1
3	Accelerating voltage	1.1
4	Magnification	1.1
5	Electron diffraction	1.2
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7	Imaging system	1.3
8	Imaging mode switch	1.4
9	Intermediate tube	1.4
10	Viewing chamber	1.4
11	Specimen airlock	1.5
12	Specimen cartridge, specimen stage	1.5
13	Anticontaminator	1.5
14	Vacuum system	1.6
15	Photography system	1.7

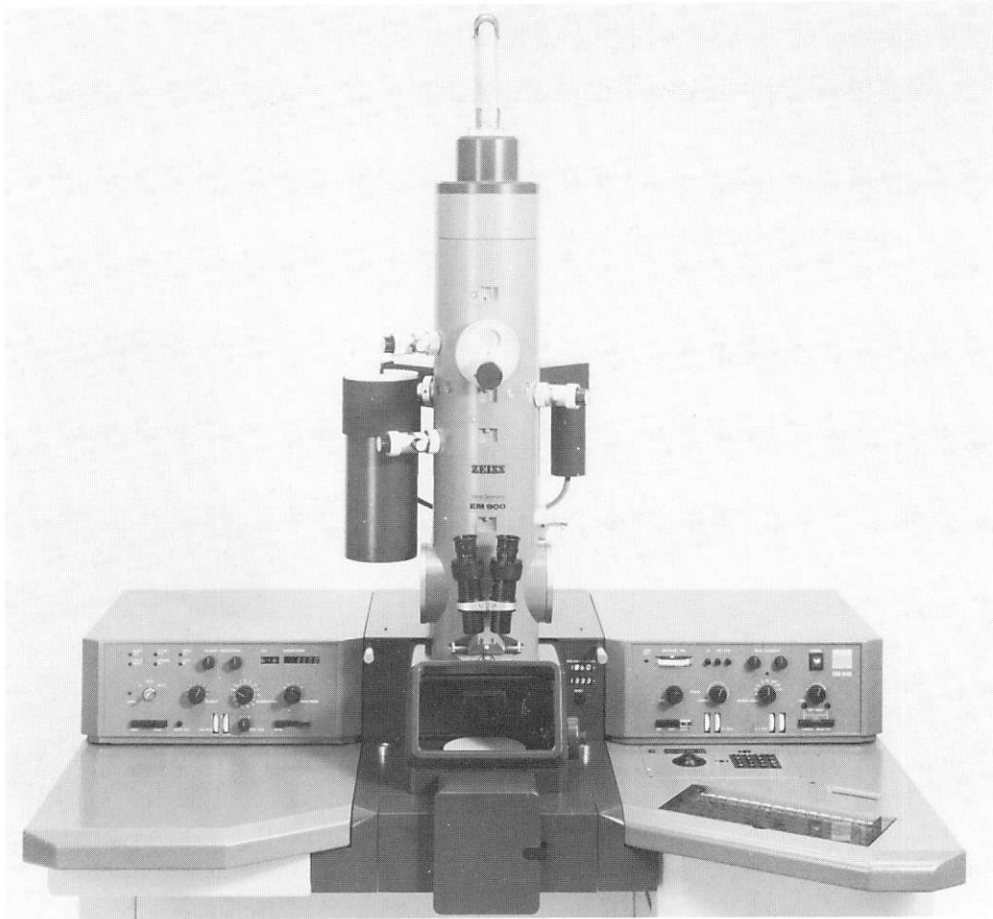


15.2

TFP camera: programmable for 60mm roll film with 8 and 16 frames (type 120 and 220) and 70mm roll film with 8, 16 and 32 frames;
Picture size: 60x72mm or 62x72mm, constant image distance;
Automatic film advance with control of leader and trailer;
Digital frame and film reserve counter with display if new film must be loaded;
Documentation data on the negative: automatic imprint of code number, 4-digit consecutive number, magnification and high-voltage codes;
Fiber optics plate with transparent fluorescent screen.

2.0 Installation, supply, accessories

Chapter		Page
1	Power requirements	2.1
2	Cooling	2.2
3	Operation and installation requirements	2.3
4	Dimensions	2.4
5	Supply	2.5
6	Accessories (optional)	2.7



Supply

The EM 900 is delivered to the installation site fully assembled and with evacuated column. Rotary pump, power supply and oil mist filter are packed in separate transport cases. The instrument can be started if vacuum system, high voltage, power cable and water supply are connected.

Chapter 1: Power requirements

1.1 Tight connection to three-, two- or single-phase lines

Voltage: 208V \pm 10% to 220V + 10%, -15%

Frequency: 50 or 60Hz

Power consumption base instrument: 4.5kVA

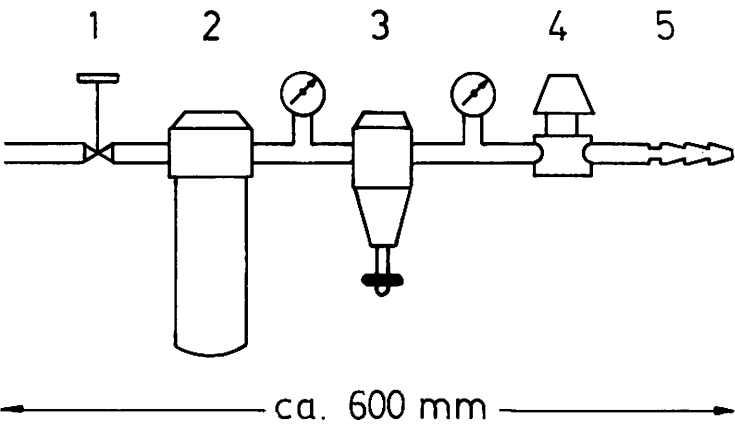
Max. power consumption with accessories: 5.5kVA

Circuit	Rated voltage 50 or 60Hz	Tolerance		Connection	Rated current*/A			Division of line connection Cross section Type	
		+	% -		L1	L2	L3		
3/N	380/220V	10	15	3-phase	10(16)	15(16)	4(6)	5 x 2.5mm ²	old: NMHou new: H05RN-F
				2-phase ^{xx}	14(16)	15(16)	-	4 x 2.5mm ²	
				1-phase	29(35)	-	-	3 x 4mm ²	
3/N	220/127V	10	15	2-phase ^{xx}	14(16)	15(16)	-	4 x 2.5mm ²	
				1-phase	29(35)	-	-	3 x 4mm ²	
3/N	208/120V	10	10	2-phase ^{xx}	15	15	-	4 x AWG 12	SO-124
				1-phase	30	-	-	4 x AWG 10	SO-104
2/N	440/220V	10	15	2-phase ^{xx}	14	15	-	4 x AWG 12	SO-124
				1-phase	29	-	-	4 x AWG 10	SO-104

* Rated current of fuses in brackets

xx Switch L1 and L3 parallel with 2-phase circuit

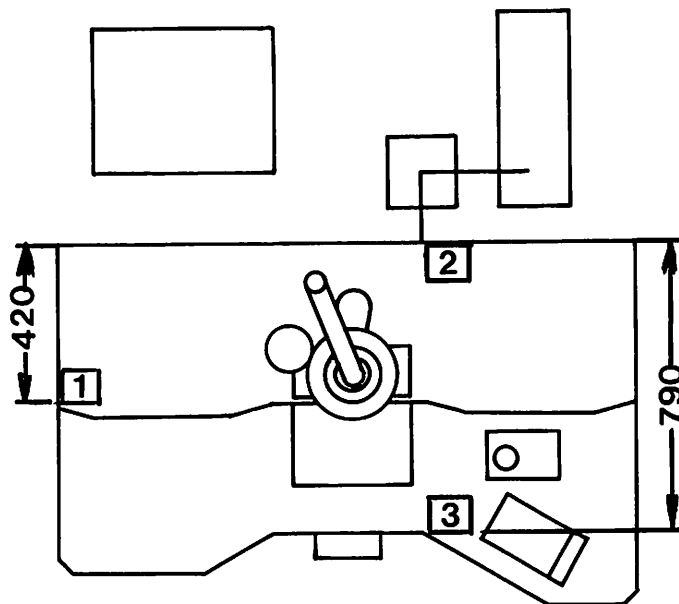
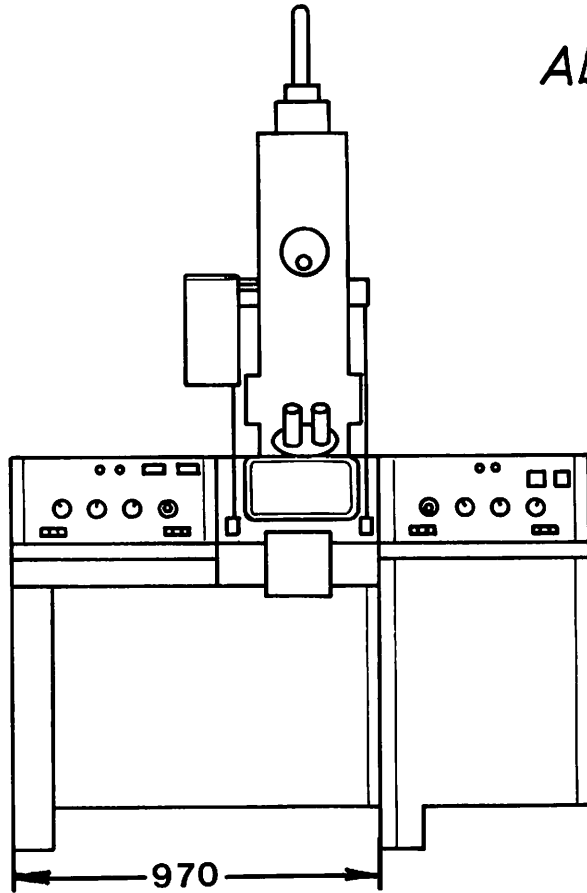
1.2 Adjustment to other lines by transformer upon request.



Chapter 2: Cooling

- 2.1 Water cooling only for lenses with thermal switchoff in case of water supply failure.
Water consumption: 2l/min
Water pressure: 2.5-3.5bar
Input temperature T_E : 15-20°C
Temperature stability: 1°/h
- 2.2 Closed-loop cooling system for EM 900
Water-cooled system (Cat.No. 34 08 80)
Cooling capacity >2.3kW at 20°C
Tap water temperature < 30°C
Negligible heat emission
Air-cooled system (Cat.No. 34 08 81)
Cooling capacity: 2.25kW at 20°C
Ambient temperature <30°C
Heat emission max. 3kW
- 2.3 Tap water connection
Supply R ½" or R 3/8"
Required: magnetic valve (38 00 67 2220 000 for 220V 50Hz or 38 00 76 5130 000 for 220V 60Hz)
Recommended: battery with filter (Fig. 1)
(1) faucet, (2) water filter, (3) pressure reducing valve, (comprehensive Cat.No. of the 3 items: 37 00 00 0119 369),
(4) magnetic valve (same as above), (5) nozzle for 8mm inside tube dia. (10m tubing included in base equipment; additional tubing of specified length available under Cat.No. 37 00 00 0054 144).

Abb.2



Chapter 3: Operation and installation requirements

3.1 Radiation shielding

X-ray dose in all operating conditions: $<36\mu\text{A}/\text{kg}$ (0.5R/h)
at a distance of 5cm from the instrument surface

3.2 Installation requirements

The following requirements must be fulfilled to assure that the guaranteed resolution is obtained at 80kV:

Magnetic strayfield (50 or 60Hz) $0.6\mu\text{T}$ ($=6\text{mG}=4.8\text{mA}/\text{cm}$) at objective lens level.

Vibrations of building: permissible peak-to-peak excursion
 $5\mu\text{m}$ at 5Hz

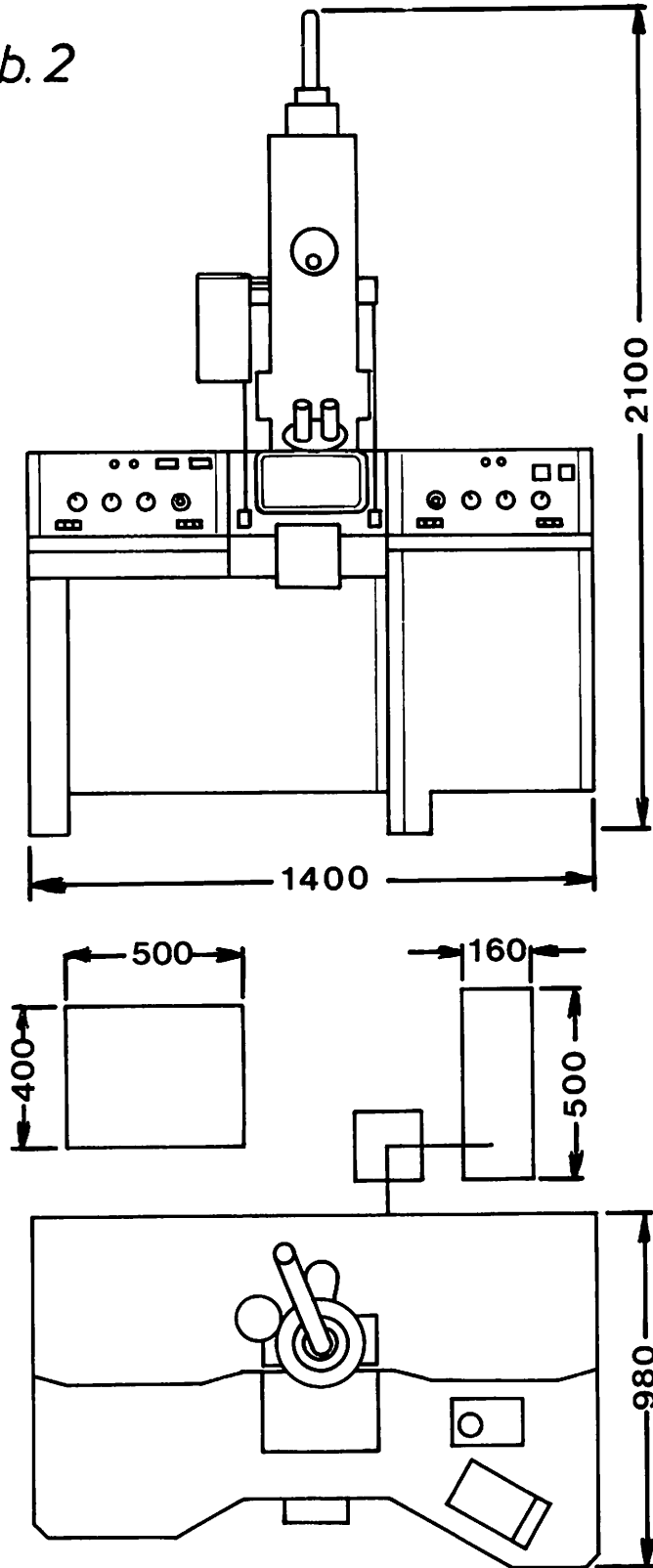
Minimum room size (length x width x height): 2.8x2.8x2.45m.

Permissible relative humidity: $<75\%$ at 25°C ; air condition must be provided if the relative humidity is higher.

Minimum door size (width x height): 800x2000mm.

Floor: solid, preferably concrete floor. Soft floor covering must be cut out at the contact points 1, 2 and 3 of the floor load plan (Fig. 2), and solid plates of corresponding thickness provided instead (minimum supporting surface in each point 100cm^2). Plates of the same size should be used on floating floor.

Abb. 2



- 3.3 Waste gas line of rotary pump
Ending outside EM room, nozzle for 8mm inside tube dia.
(5m tubing supplied);
Alternatively: oil mist filter and waste gas line.
- 3.4 Ventilation of microscope column with dried nitrogen
Pressure reducer (primary to 200bar, secondary adjustable),
with range display; adjustable ventilation pressure 0.2bar;
nozzle for 6mm inside tube dia., length of tubing
according to specification.

Chapter 4: Dimensions and weight of instrument (Fig. 2)

Microscope (length x width x height): 1400x980x2100mm

Weight: 600kg

Chapter 5: Supply

5.1	EM 900 with sheet film camera and electronic specimen positioning	34 58 29
5.2	EM 900 PC with sheet film camera and manual specimen shift	34 58 27
5.3	EM 900 TFP with TFP camera and manual specimen shift	34 58 28

5.1 comprises:

Base instrument, electronic specimen positioning,
sheet film camera and standard equipment in addition to
the above specification:

- 1 specimen cartridge with slide ea. for HC and HR modes
- 40 sheet film holders 3¼x4"
- 1 exchangeable magazine for sheet film holders
- 1 container for sheet film holders
- 1 film transport container

5.2 comprises:

Base instrument with sheet film camera

Same equipment as specified under 5.1, but without
electronic specimen positioning

Specimen stage

- manual drives
- 2mm travelling range in X and Y

5.3 comprises:

Base instrument with TFP camera

Same equipment as EM 900 PC, but without electronic specimen positioning and TFP instead of sheet film camera

Specimen stage

- manual drives
- 2mm travelling range in X and Y

TFP camera

- Outside-the-vacuum Trans-Fiberoptic-Photography system
- Fiber-optics plate coated with polycrystal fluorescent material
- 60mm roll film (type 120 or 220) for 8 or 16 frames
- 70mm roll film for 8, 16 or 32 frames
- Automatic film advance
- Automatic exposure control
- Automatic imprint on the negative of user code, 4-digit consecutive frame number, magnification and high-voltage codes
- Density of image and data separately adjustable

Standard equipment in addition to the above specifications:

- 1 specimen cartridge with slide ea. for HC and HR modes
- 1 leader and trailer for 70mm roll film
- 1 reel for 70mm roll film, in case

Chapter 6: Optional accessories

6.1 High-resolution goniometer

45° high-resolution goniometer

Tilt +/- 45°

Rotation 0-360°

Complete equipment with universal motor control unit

(34 07 71.9901) and

45° goniometer cartridge (34 07 58.9101)

Cat.No. 34 07 58

60° high-resolution goniometer

Tilt +/- 60°

Rotation 0-360°

Complete equipment with universal motor control unit

(34 07 71.9901) and

60° goniometer cartridge (34 07 89.9101)

Cat.No. 34 07 89

Spares for goniometer system:

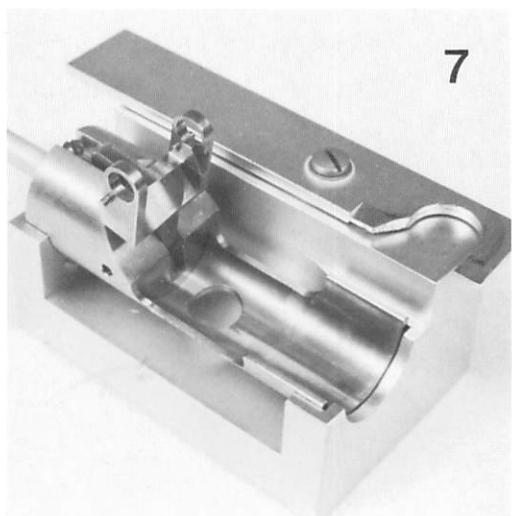
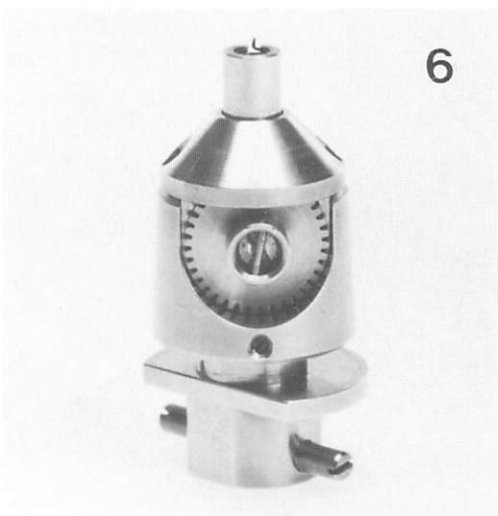
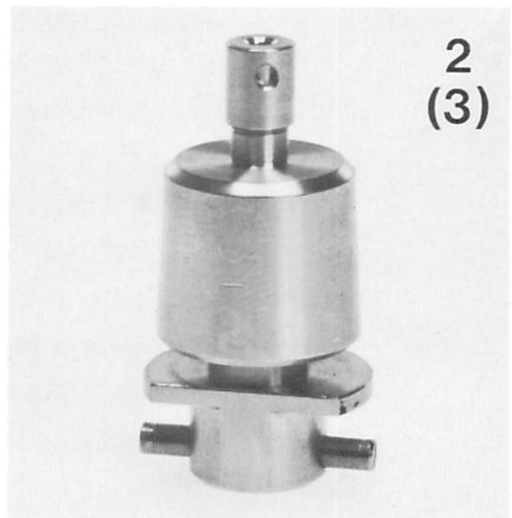
Multiple, lifting and rotation cartridges

20 spare retaining rings

in case 34 07 58-0044 (Id.No. 89 429)

ring lifter 34 07 58-1109

adjusting device 34 07 58-8003



6.2 Other cartridges

- 1 Goniometer cartridge for 3mm dia. specimen grids
Tilt +/- 45°
Rotation 0-360°
Cat.No. 34 07 58.9101
Goniometer cartridge for 3mm dia. specimen grids
Tilt +/- 60°
Rotation 0-360°
Cat.No. 34 07 89.9101
- 2 Standard cartridge for 3mm dia. specimen grids,
for HR mode
Cat.No. 34 07 22-9901
- 3 Standard cartridge for 3mm dia. specimen grids,
for HC mode
Cat.No. 34 07 70-8001
- 4 Multiple cartridge for 3mm dia. specimen grids
Cat.No. 34 07 57-9901
- 5 Lifting cartridge for 3mm dia. specimen grids
Cat.No. 34 07 70-9901
- 6 Rotation cartridge for 3mm dia. specimen grids
Cat.No. 34 07 65
- 7 Cartridge slide in case
Cat.No. 34 07 20-8062.010

Multiple cartridge for three 3mm dia. specimen grids;

required: right-hand drive, Cat.No. 34 07 49

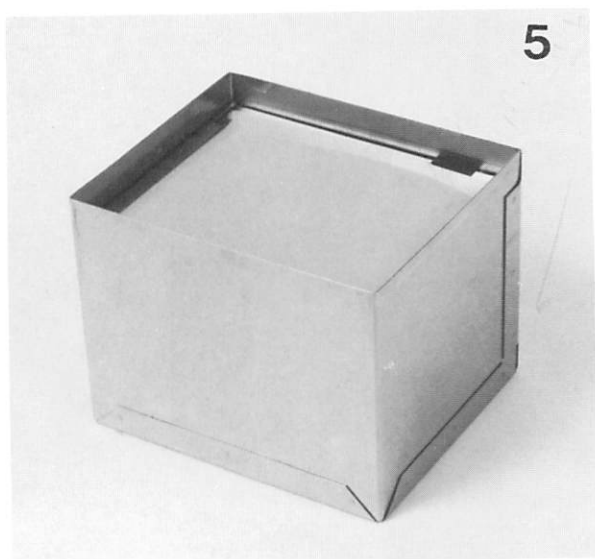
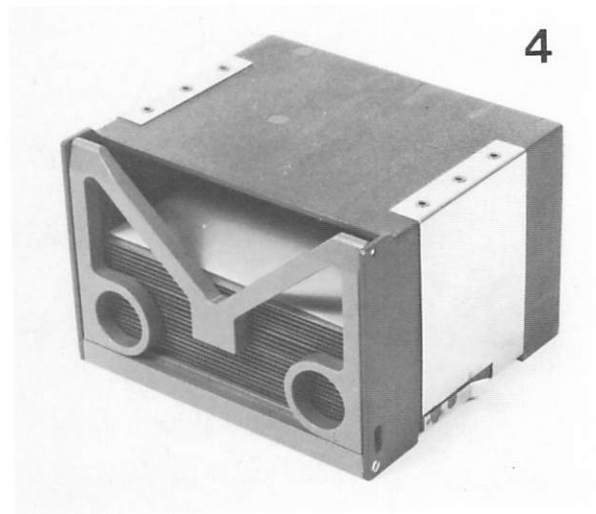
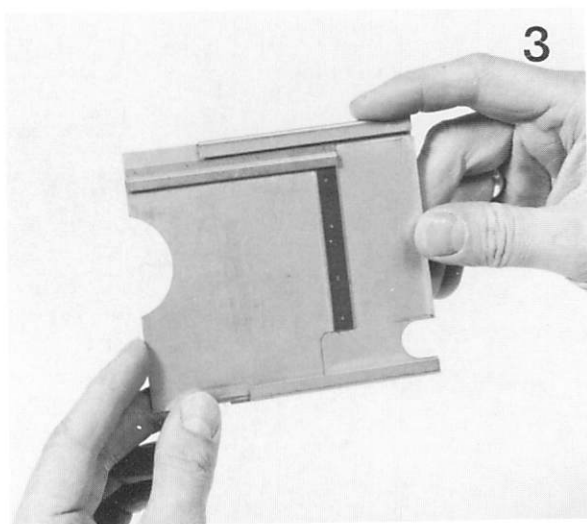
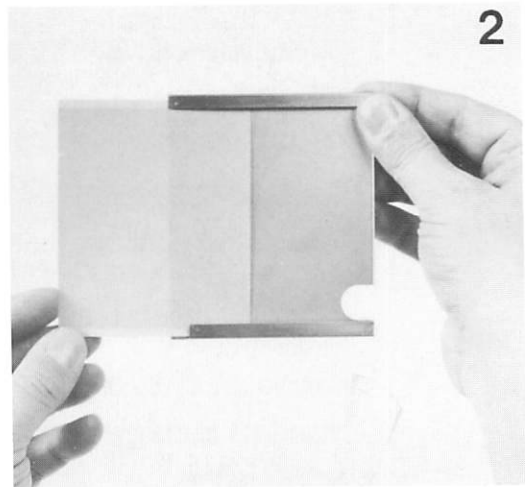
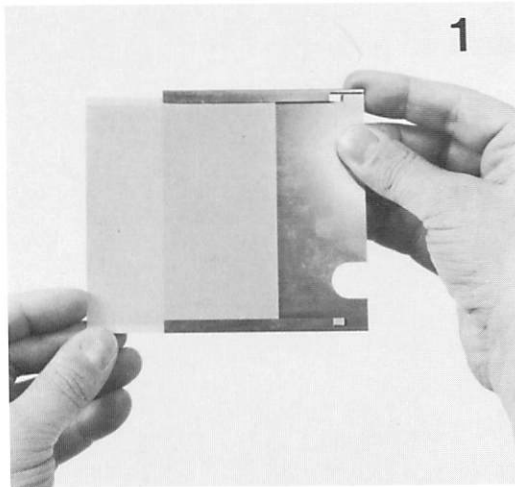
or motor control unit

Rotation cartridge for 3mm dia. specimen grids,

rotation 0-400°;

required: left-hand drive, Cat.No. 34 07 49-9901

or motor control unit



6.3	Accessories for sheet film camera	
1	Sheet film holder 3¼x4" Cat.No. 34 07 45.9904	40
2	Plate/sheet film holder 3¼x4" Cat.No. 34 07 45	20
3	Adapter 6.5x9cm for plate/sheet film holder 3¼x4" Cat.No. 34 07 54	20
4	Exchangeable magazine for 40 sheet film or 20 plate/sheet film holders for EM 109/EM 902/EM 900 Cat.No. 34 11 40.8002	2
5	Container for sheet film holder for EM 109/EM 902/EM 900 Cat.No. 34 11 40.8005	1
6	Transport container for sheet film holder for EM 109/EM 902/EM 900 Cat.No. 34 11 40.8007	1
	Developing system for plates and sheet film with thermostat and nitrogen aeration (film containers not included) Cat.No. 34 55 22.9001	1
	Film container for 20 plates/ sheet films 3¼x4" Cat.No. 34 55 29	2
	Film container for 20 plates/ sheet films 6.5x9cm Cat.No. 34 55 24	2

6.4 Accessories for TFP camera

Roll film type TP 120 for TFP camera
 8 frames
 Kodak Technical-Pan 6415
 Cat.No. 34 57 61

1

AVI-Ortho 25 70mm roll film
 1 roll with 30m film
 Cat.No. 34 57 77

1

Leader and trailer for 70mm film
 Cat.No. 34 09 41.0003

1

Film reel for 70mm film, in case
 Cat.No. 34 56 58

1

Rewinder for 70mm film
 Cat.No. 34 09 71

1

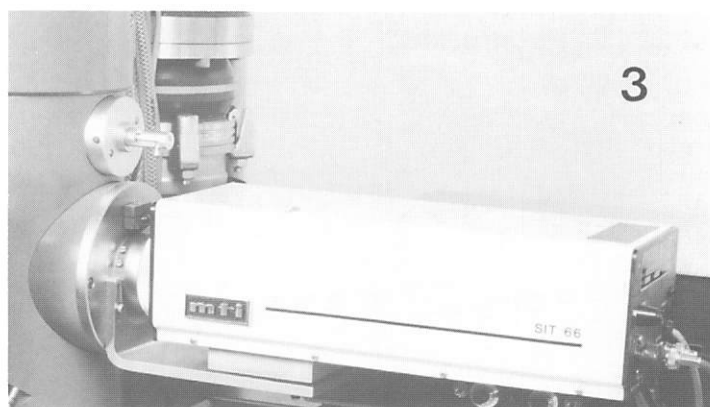
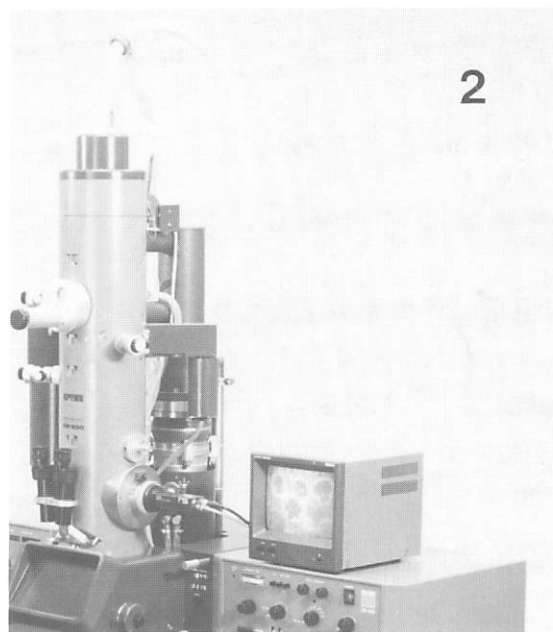
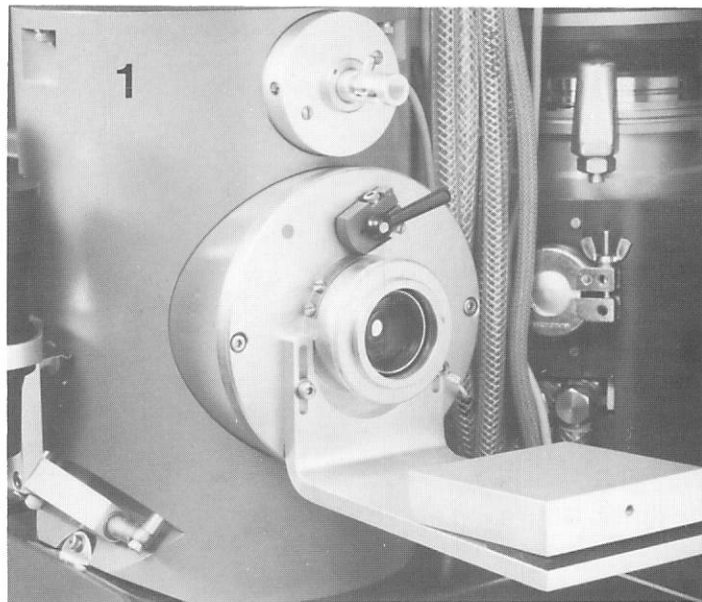
Tiltable developing tank
 for 70/60/35mm roll film
 Cat.No. 34 57 01

1

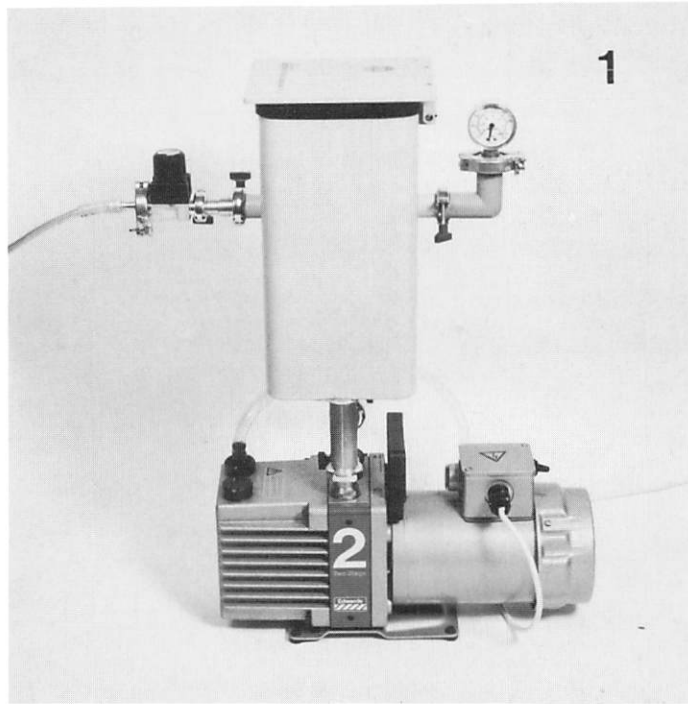
6.5 35mm camera (alternative to TV/CCD camera)

For perforated and unperforated 35mm roll film;
 Roll film cassette for commercial 35mm cartridges;
 Capacity: 45 frames
 Frame size: 23x27mm, constant image distance,
 magnification factor 0.3;
 Automatic film advance with 3-digit, reset
 frame counter
 Cat.No. 34 09 49

Roll film cassette for 35mm camera
 Cat.No. 34 07 42.9002



- 6.6 1 TV adapter for EM 109/EM 10/EM 902/EM 900
- TV adapter (C mount) to mount either a CCD, Pasecon or image intensifier camera;
Transfer to the camera target via swing-in fluorescent-screen-mirror assembly and light optics, magnification factor 0.27 on camera target
Cat.No. 34 09 53 (contained in camera ordering number)
- 6.7 2 TV and CCD systems with widefield imaging
- CCD system for EM 109/EM 902/EM 900
CCD camera
1 monitor, cable and CCD adapter
Cat.No. 34 58 17 1
- 6.8 3 Image intensifier system for EM 109/EM 901/EM 900
- SIT camera (Dage)
1 monitor and TV adapter
Cat.No. 34 57 70
- 6.9 TV system for EM 109/EM 902/EM 900
- Camera with Pasecon tube, monitor, cable and TV adapter
Cat.No. 34 57 41 1



6.10 Sector diaphragm (alternative to TV/CCD camera or 35mm camera)

Diaphragm insert with coaxial drives to swing the diaphragm carrier in and out and to rotate the diaphragm through 45° click stops;
4 types of format division: 1x180° (half sector for imaging mode), 1x90° (quarter sector for imaging mode), 2x90° (diametrical, for diffraction images), 4x45° (90° displaced, for diffraction images)

Cat.No. 34 07 73

6.11 1 Desiccator with valve for nitrogen ventilation for sheet film and roll film

For pre-drying of film material;
9l drying chamber mounted on rotary pump (3m³/h), set up separately

Cat.No. 34 57 68

6.12 Image analysis and host computer

Videoplan for morphometry and remote control of sheet film camera and electronic specimen positioning, including interfaces, interface adapter plug, cable and control program

Cat.No. 99 99 99

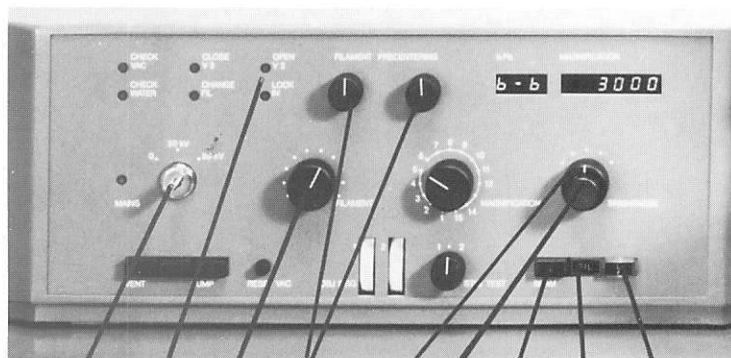
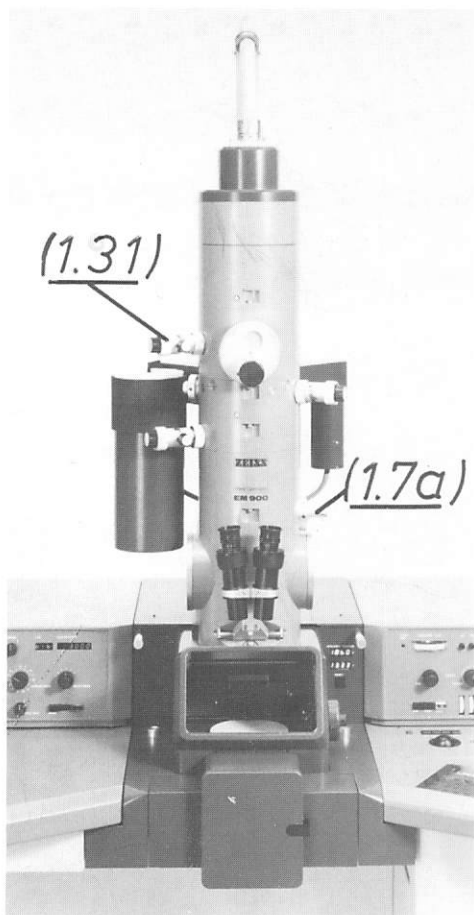
6.13	Nitrogen ventilation of the column is absolutely necessary! Valve with 1" inside thread for connection to a nitrogen cylinder (DIN 477) Cat.No. 34 56 59	1
6.14	Water-cooled closed-loop cooling system CZ 2250 W Cat.No. 34 08 80	1
6.15	Air-cooled closed-loop cooling system CZ 2250 L Cat.No. 34 08 81	
6.16	Water supply with magnetic valve required for tap water supply of EM 900: Water supply of electron microscopes Cat.No. 34 09 00.8904	1
6.17	Magnetic valve 220V 50Hz 495/10-ar 3/8/16 Cat.No. 00 00 00.0067.222	1
6.18	Oil mist filter for EM 900 Cat.No. 34 56 56	1
6.19	Expandable material for EM 109/EM 900 Cat.No. 34 09 63	1
6.20	Spare parts for EM 109/EM 900 Cat.No. 34 09 64	1
6.21	Filament hour counter for EM 109/Em 902/EM 900 Cat.No. 34 09 57	
6.22	Dewar vessel 25 LD for liquid nitrogen Cat.No. 34 57 52	1
6.23	Tip cart for Dewar vessel 25 LD Cat.No. 34 57 53	1
6.24	Transformer 5kVA for 200, 240/220V for EM 109/EM 902/EM 900 Cat.No. 34 09 72	1

6.25 Apertures and expandable material

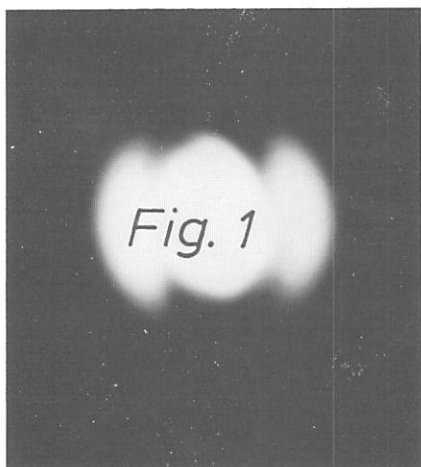
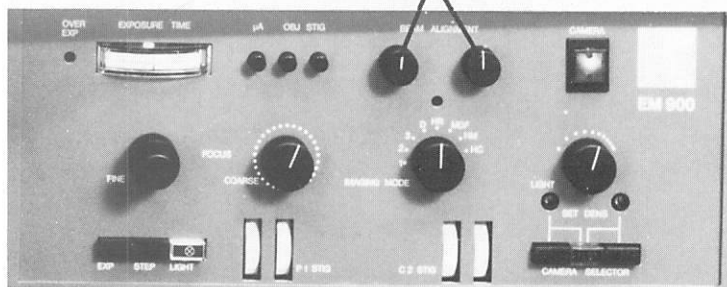
Condenser/intermediate image aperture 0.400mm/Mo Cat.No. 34 07 29.0001	1
Condenser/intermediate image aperture 0.200mm/Mo Cat.No. 34 07 29.0002	1
Condenser aperture 0.100mm/Mo Cat.No. 34 07 29.0003	1
Annular condenser aperture for darkfield imaging (34 83 25.8008 required) Cat.No. 34 07 29.8020	1
Intermediate image aperture 0.050mm/Mo Cat.No. 34 07 29.8010	1
Thin-film aperture 0.03mm Cat.No. 34 07 29.8010	1
Thin-film aperture 0.04mm Cat.No. 34 83 25.8008	1
Thin-film aperture 0.06mm Cat.No. 34 07 29.8011	1
Thin-film aperture 0.09mm Cat.No. 34 07 29.8012	1
Seven-hole thin-film aperture 4x0.03mm, 3x0.06mm Cat.No. 34 07 29.8014	1
Specimen grid type 200/3mm 1 package of 100 pieces Cat.No. 34 54 10	1
Case for 100 specimen grids Cat.No. 45 54 13	1

3.0 Brief operating instructions EM 900

Chapter		Page
1	Instrument switch-on	3.1
2	Electron-beam switch-on	3.1
3	Adjustment of filament heating	3.1
4	Condenser aperture	3.1
5	Condenser stigmator	3.2
6	Projector lens stigmator	3.2
7	Contrast aperture	3.2
8	Focusing	3.2
9	Compensation of objective lens astigmatism	3.3
10	Operation of sheet film camera	3.3
11	Operation of TFP camera <i>not used on EM900</i>	3.7
12	Operation of 35mm camera <i>not available</i>	3.8
13	Specimen exchange	3.9
14	Lock-in	3.9
15	Low magnifications 150x, 1 100x	3.9
16	Adjustment in HC mode	3.10
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(3.11) (3.17) (3.12) (3.22) (3.24)
 (3.4) (3.5) (3.13) (3.23)
 (4.6)



Chapter 1: Instrument switch-on

Key switch (3.11) to I (50kV) or II (80kV)

Chapter 2: Electron-beam switch-on

Wait for go-ahead for valve V 3 (1.7a). Diode OPEN V3 (3.4) lights. Open V 3.

Green key (3.22) displays high-voltage go-ahead. Pushing this key (3.22) switches on the high voltage, red key (3.24) lights and displays activated high voltage.

Pushing the key FIL (3.23) activates the filament.

Chapter 3: Adjustment of filament heating and optimized brightness

Specimen out of, condenser aperture in beam path, magnification 3000x.

Narrow condenser to crossover with condenser potentiometer BRIGHTNESS (3.13); set beam current to step 5 with switch BRIGHTNESS (3.12); underheat filament with FILAMENT (3.17); underheated filament image centered in luminous spot corresponding to Fig. 1.

Correction: symmetrize shadow image with centering potentiometers FILAMENT PRECENTERING (3.5), increase filament heating with FILAMENT (3.17) until the luminous spot is homogeneous.

Chapter 4: Condenser aperture

Turn condenser clockwise until the shadow image of the aperture is somewhat smaller than the large fluorescent screen; center the aperture image with the potentiometers BEAM ALIGNMENT (4.6); turn condenser anticlockwise: the aperture image is in the same position and changes concentrically to the center of the fluorescent screen.

Correction: with aperture drive (1.31) shift aperture image towards the center of the fluorescent screen by half the observed excursion distance. Repeat the procedure several times.

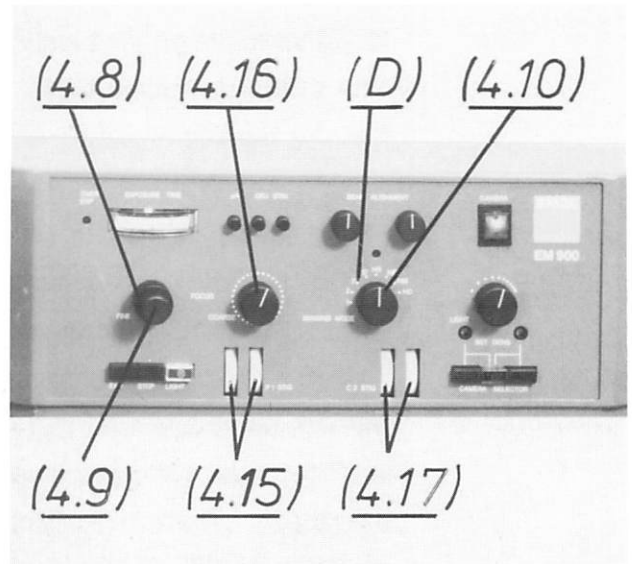
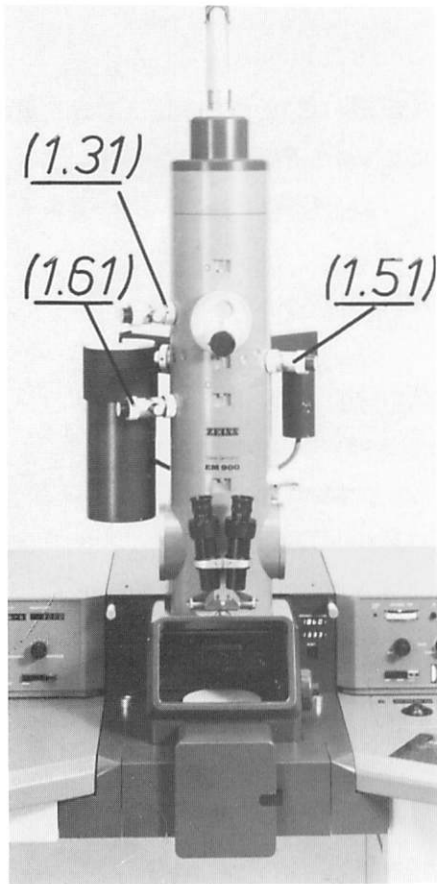


Fig. 2

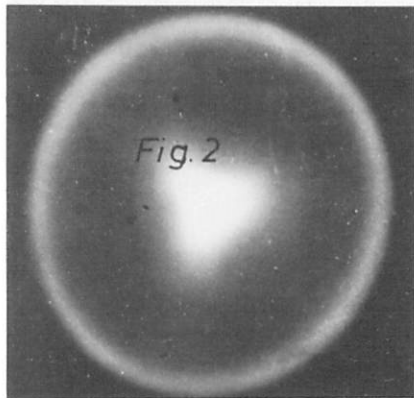
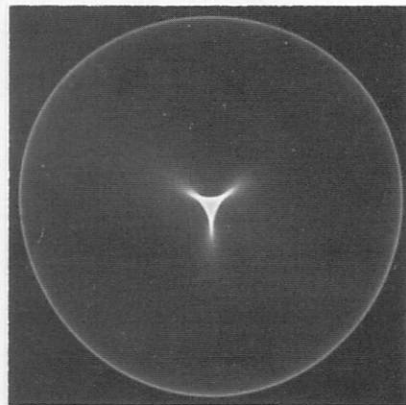


Fig. 3



Chapter 5: Condenser stigmator

The elliptical shape of the crossover on the small fluorescent screen is identical in under- and overfocus.

Or: with retracted condenser and contrast apertures (1.31)-(1.51) image condenser caustic with condenser potentiometer corresponding to Fig. 2 (beam current to step 1).

Correction with C2 stigmator (4.17).

Insert condenser aperture and center as described in Chapter 4.

Chapter 6: Projector lens stigmator

Turn condenser far clockwise, set mode switch (4.10) to D; image diffraction caustic with P1 potentiometer (4.9) corresponding to Fig. 3.

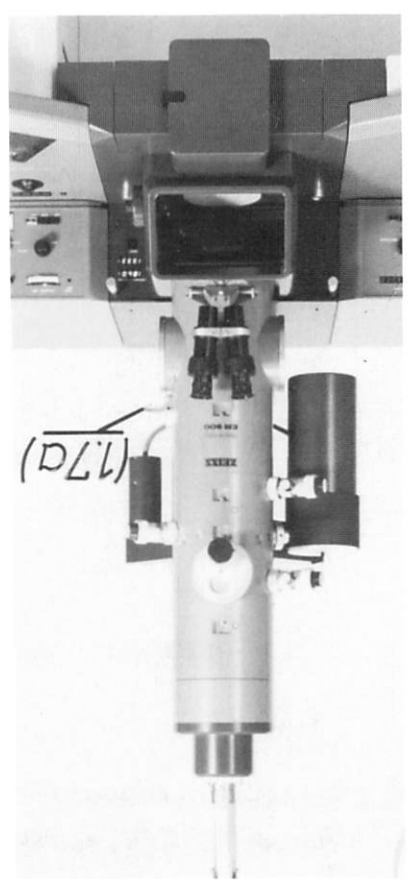
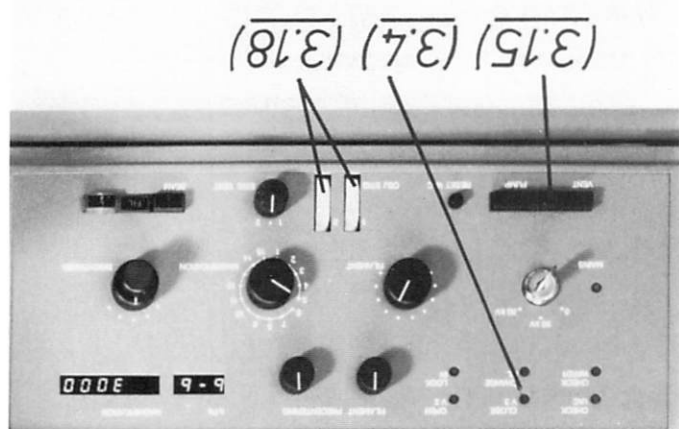
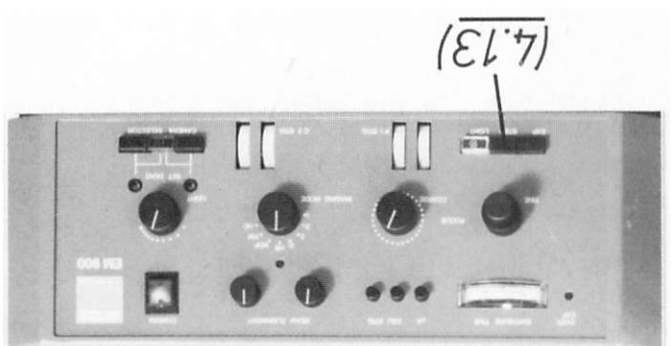
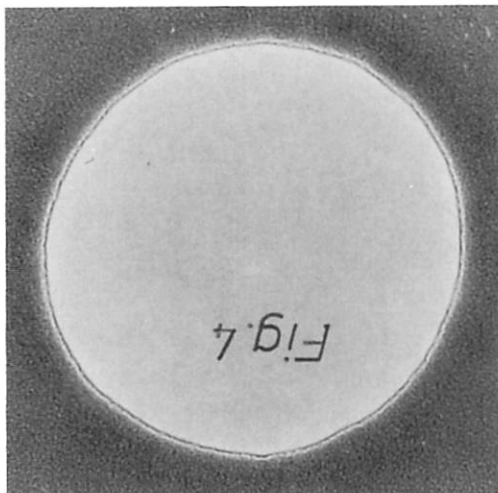
Correction with P1 stigmator (4.15).

Chapter 7: Contrast aperture

Mode switch (4.10) to HR; perforated foil in beam path; insert largest 400 μ m selector aperture (1.61) and center; mode switch to D; focus diffraction spot with P1 potentiometer (4.9); insert desired contrast aperture (1.51) and center with reference to the diffraction spot; mode switch to HR; retract selector aperture (fully anticlockwise).

Chapter 8: Focusing

Focus specimen with digital focusing knob FOCUS (4.8). If the focus is not obtained when focusing through the entire range (between 2 major focus jumps), use coarse focusing control COARSE (4.16) and focus with digital focusing knob. Pushing the key MEDIUM (4.13) increases the focusing steps by the factor 4, which accelerates the focusing process.



Chapter 9: Compensation of objective lens astigmatism

Using perforated foil: 85000x or higher magnification; slightly overfocused diffraction fringe concentric to the hole corresponding to Fig. 4

Using grain: at 140000x magnification no privilege direction of foil structure when through-focusing in fine-focusing steps.

Correction with objective lens stigmator (3.18).

Chapter 10: Operation of sheet film camera

10.1 Loading of films

Switch off filament and high voltage.

Close valve V 3 (1.7a) manually.

Push key CAM (3.15); the camera chamber is ventilated.

Turn off room light and desk lamp.

Open camera, take out empty magazine.

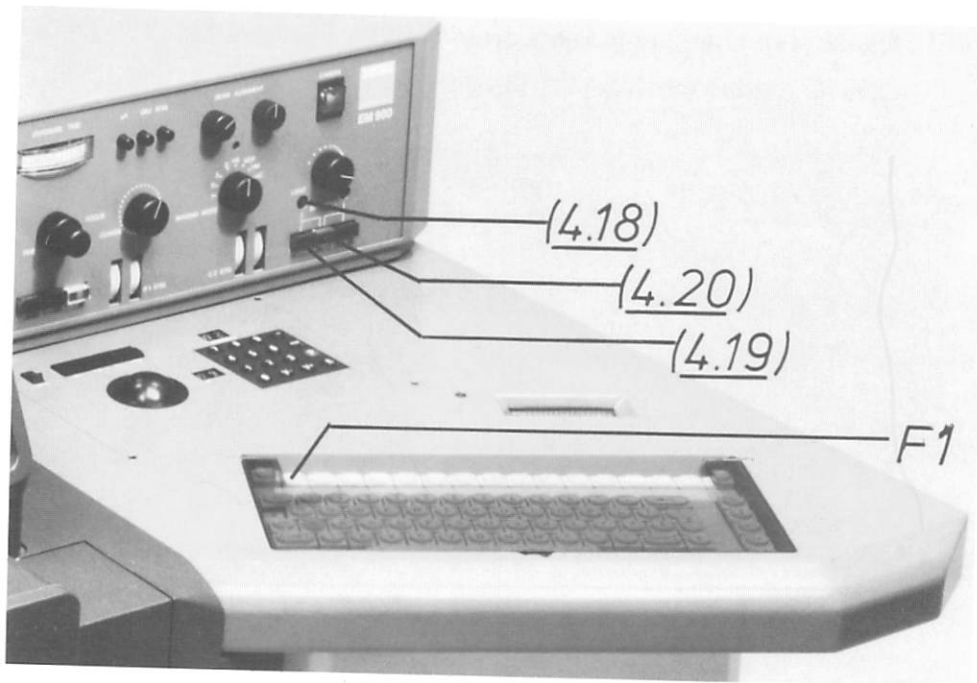
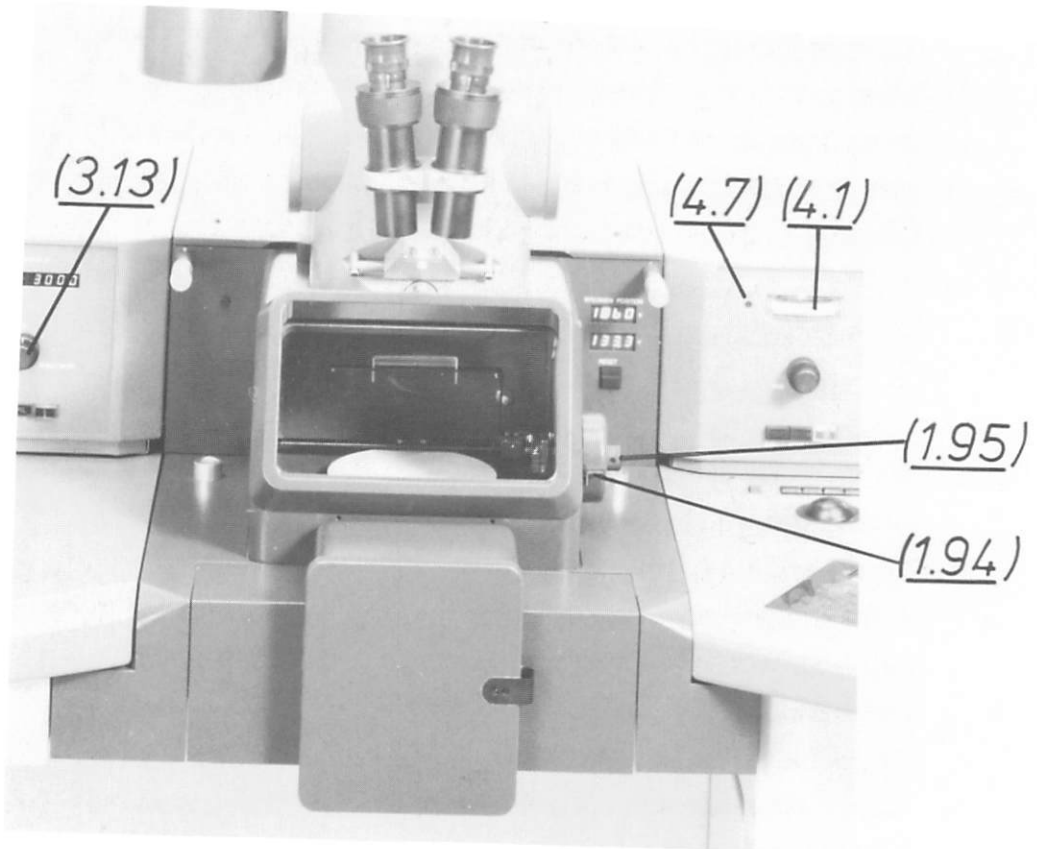
Insert pre-dried film magazine in camera.

Check magazine for correct fitting.

Take exposed films out of container and put them in light-tight transport container.

Close camera door, lock it and release key CAM (3.15);

the camera chamber is evacuated. Wait until lamp OPEN V3 (3.4) lights. Key in data for loaded film from the keyboard.



10.2 Film speed setting

The density is adjusted for the F1 mode of the sheet film camera with potentiometer (4.18). The adjusted value is displayed on (4.1) when key TEST (4.20) is pushed.

The adjusting value (on a scale from 0 to 100) is dependent on the film type and must be determined by an exposure series. Vary the density in steps of 10 scale divisions and expose (without specimen).

10.3 Photography (F1 single exposure mode)

Successively activate the following keys after switch-on of the sheet film camera:

F1 single exposure mode

Camera selector 60/70 (4.19) on EM

Potentiometers (4.18) on the EM to set the film speed

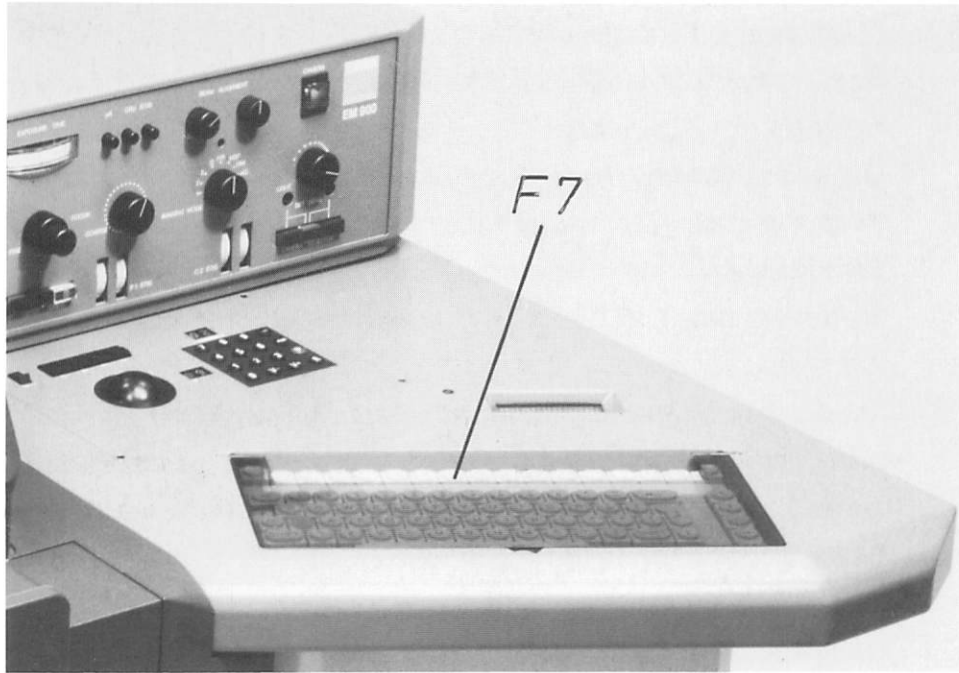
For the exposure time: select the brightness with BRIGHTNESS (3.13) on the EM so that the lamp OVER EXP (4.7) is out and the photographic format fully illuminated.

The small fluorescent screen must be swung down completely for correct measurement of the electron intensity which determines the exposure time (knob (1.95) for the small fluorescent screen must be turned fully anticlockwise)

Select a specimen feature and focus.

Release exposure by raising the large fluorescent screen (1.94). Exposure is started automatically.

The exposure START key on the EM need not be pushed.



10.4 Film density setting

Push key F7 twice for input of film density and select density values between 0.1 and 999. Change the value in steps of 0.1 by inputs from the keyboard, and expose (without specimen).

Conventional films have speeds between 0.1 and 10.0.

Definition of film speed

Kodak defines the film speed as follows:

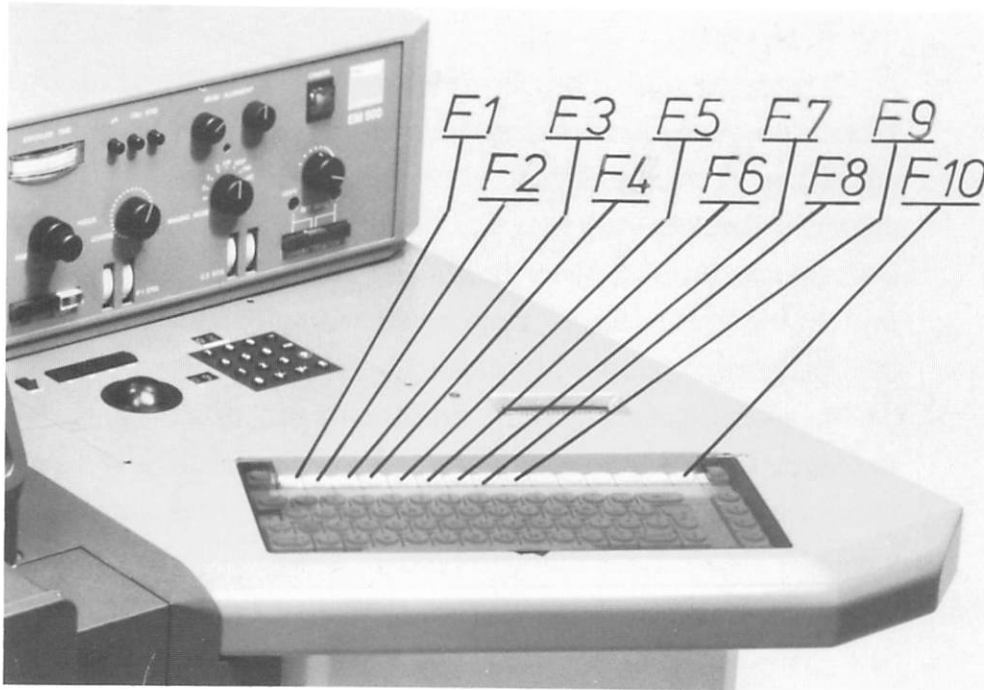
An exposure of $1/\text{film speed}$ electrons/square micrometer is required to obtain the density 1.00 above fog level (see specifications for SO 163 film, KP 77769a 7-82, at the bottom of page 1).

The film density for the sheet film/plate camera of the EM 900 is input in serial exposure mode in electrons/square micrometer $\text{el}/\mu\text{m}^2$ ($\text{el}/\text{q}\mu\text{m}$ on the display), not the film speed!

Example: Kodak SO-163 film

Development Kodak D 19 for 12 minutes, given film speed 2.2 (Kodak). By pushing the function key F7 twice input the value $1/2.2 = .45\text{el}/\text{q}\mu\text{m}$ to obtain the film density 1.00 above fog level.

If a film emulsion is exposed by electrons the density is generally proportional to the exposure, at least within more or less extended regions of the characteristic curve, the desired density can be defined by input of the proportional film density.



10.5 Photography (F2 serial exposure mode)

Successively activate the following keys:

F2 Serial exposure mode

F1 Input of user code and frame number

F2 Free input (alphanumeric)

16 characters (lower line only)

Switch back to F1 mode for free inputs of the last 6 characters of the topmost line.

F3 Display of instrument parameters

F4 Input of film reserve *# of plates in camera*

F5 Input of data imprint *density setting for data only*

F7 Pushed twice for input of film density. The camera

features an automatic exposure control of its own

(Chapter 6.0)

Special note: When pushed once the LCD displays LIFT SCREEN. Neglect this instruction and push the key again. (When the fluorescent screen is raised, the exposure time and the target current are displayed on the LCD.)

F8 Display of the cassette type (1.5 or 3mm).

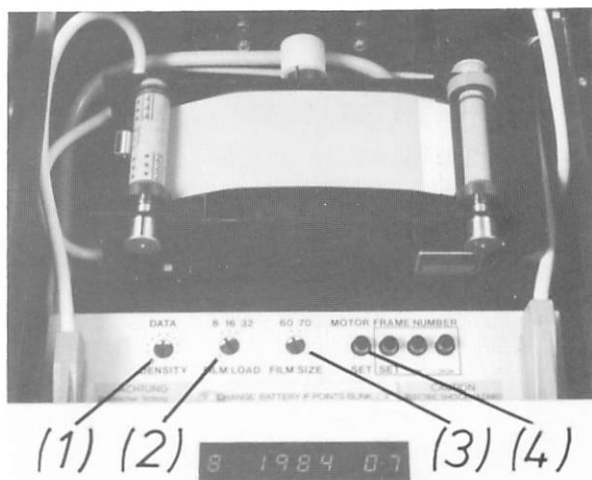
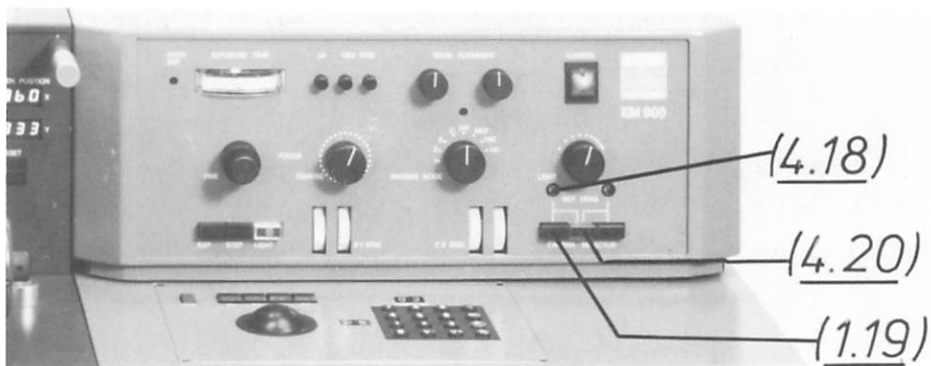
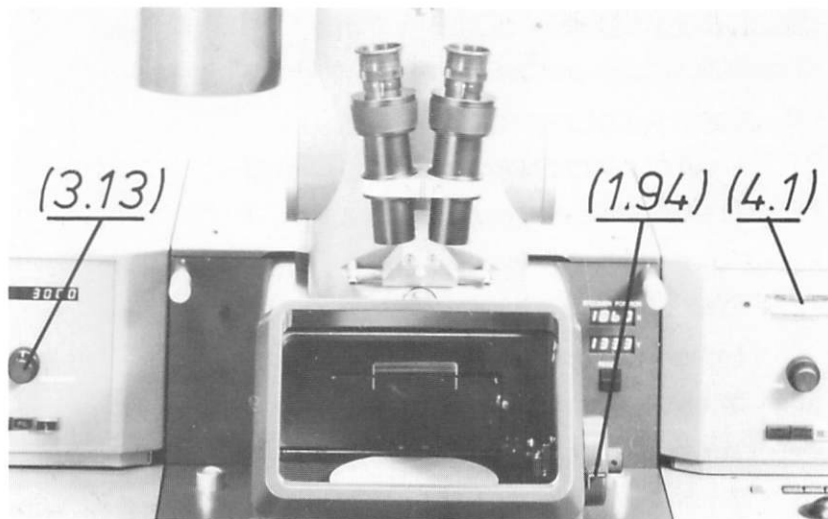
F9 The measured current is entered in the data line (instead of free inputs following the film number). Irrelevant for EM 900.

Select a specimen feature and focus

Raise the fluorescent screen

Adjust the exposure time (wait at least 2s until the time is set).

Push F10 and release exposure. Further exposures are released by pushing F10 again. The exposure time can be checked by pushing F7.



IDENT. NO. FRAME NUMBER LOAD

Chapter 11: Operation of TFP camera

11.1 Loading of films

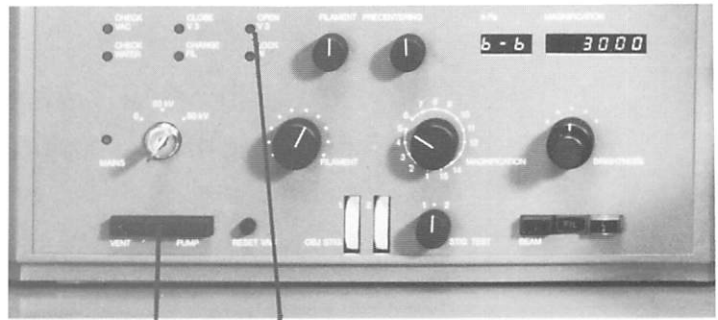
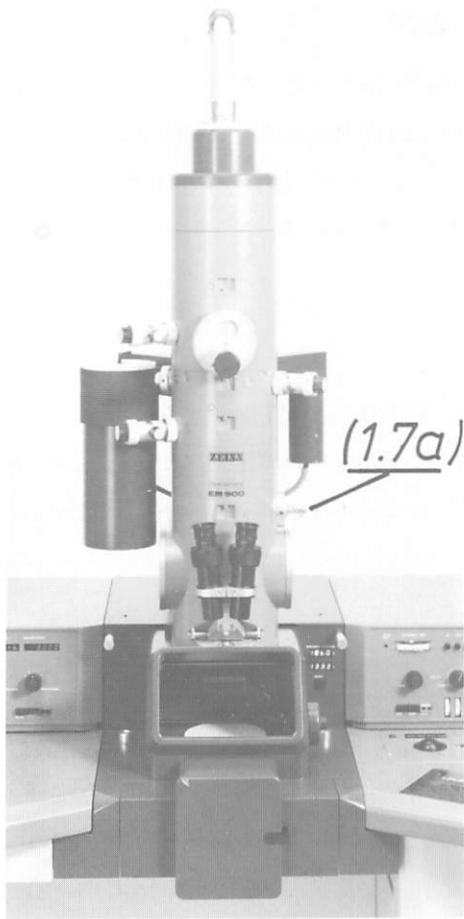
Unlock and open camera insert. Insert empty spool to the right and film spool to the left. Thread leader into right spool. Wind up film (approx. 1 revolution) by operating the key MOTOR SET (4) until the black mark (arrow, triangle) becomes visible on the film leader in the mirror. Set film format (3), number of frames (2) and data density (1). Close and lock camera insert.

11.2 Film speed setting

The film density for the 60/70mm camera is adjusted with the potentiometer (4.18). The adjusted value is displayed on (4.1) if the key TEST (4.20) is pushed. The adjusting value (on a scale from 0 - 100) is dependent on the film type and must be determined by an exposure series. Vary the density in steps of 10 scale divisions and expose (without specimen).

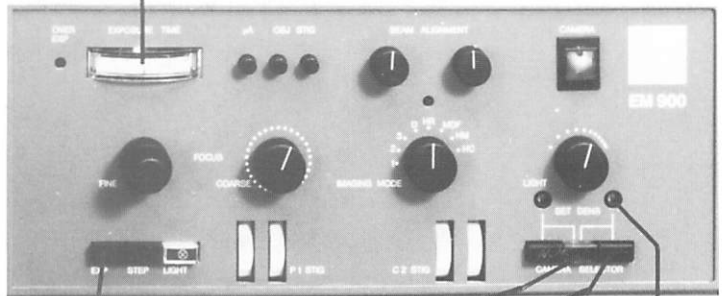
11.3 Photography with the TFP camera

Push camera selector 60/70 (4.19) and select the image brightness with the condenser potentiometer BRIGHTNESS (3.13) so that the large fluorescent screen is fully illuminated. The small fluorescent screen must be swung down. Raise the large fluorescent screen with lever (1.94) before exposure, push the key START (4.12) and wait until the light in this key goes on. slowly swing down the fluorescent screen and set lever (1.94) to lower click-stop position. The light in the key START goes out.



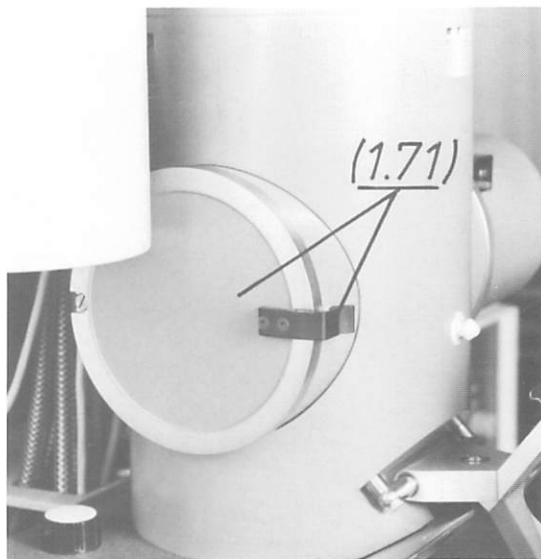
(3.15) (3.4)

(4.1)



(4.12)

(4.20) (4.21) (4.22)



(1.71)

Chapter 12: Operation of the 35mm camera

12.1 Loading of films

Manually close valve V 3 (1.7a), and push key CAM (3.15); the camera chamber is ventilated. Take off the left lid (1.71), insert pre-dried 35mm cassette and put on lid, the catch snaps in. Release key CAM (3.15); the camera chamber is evacuated. Wait until the light in the key OPEN V3 (3.4) goes on.

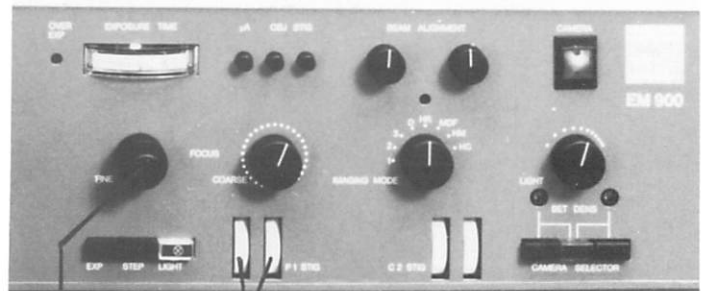
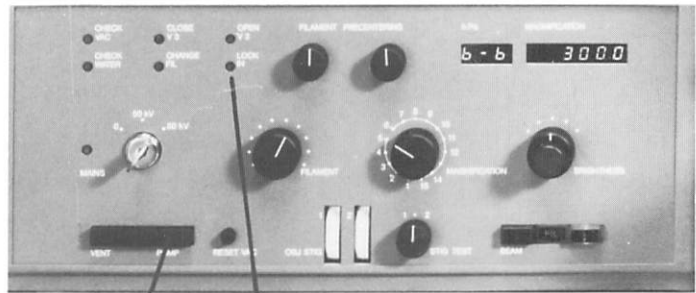
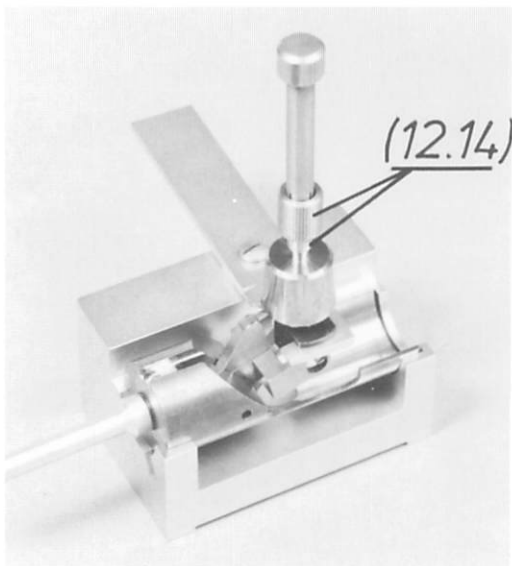
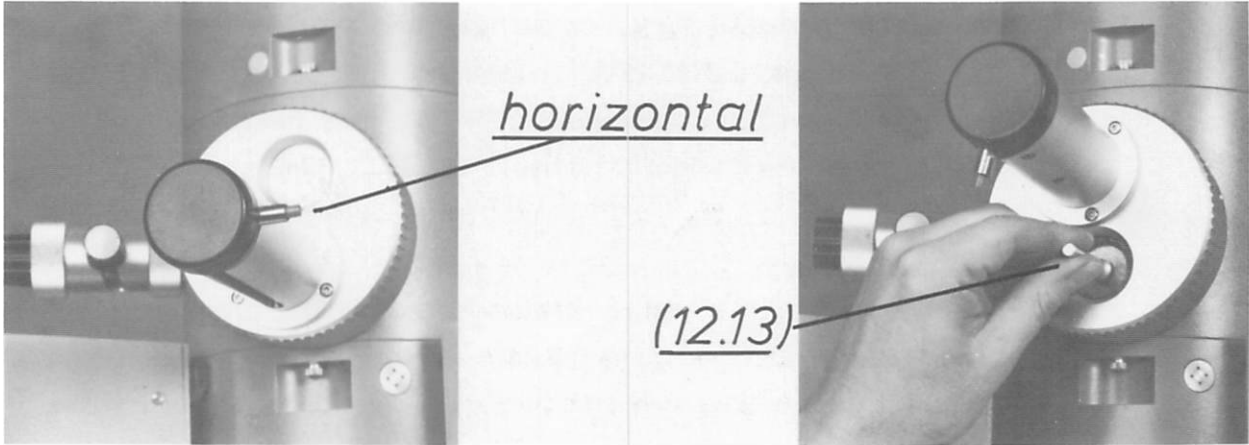
12.2 Film speed setting

The film density for the 35mm camera is adjusted with potentiometer (4.22). The adjusted value is displayed on (4.1) if the key TEST (4.20) is pushed.

The adjusting value (on a scale from 0 - 100) is dependent on the film type and must be determined by an exposure series. Vary the density in steps of 10 scale divisions and expose (without specimen).

12.3 Photography with the 35mm camera

Push key 35mm (4.21). The small fluorescent screen is in lower click-stop position. Adjust image brightness as described under 11.3 above. Pushing key START (4.12) activates camera start, film exposure and camera return with film advance.



Chapter 13: Specimen exchange

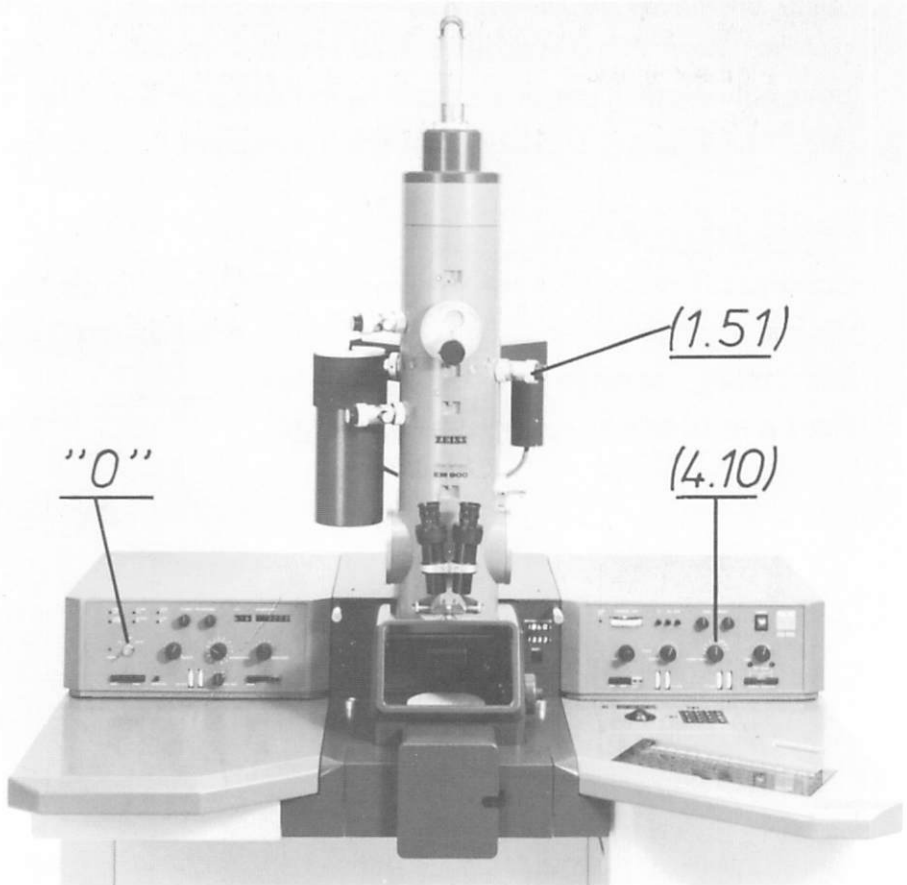
Unlock and open specimen airlock. Pull out specimen slide with wrench (12.13) and place it on the specimen changing device. Keep the airlock closed during specimen exchange. Remove screw cap with wrench (12.14), exchange specimen and put on screw cap.

Chapter 14: Lock-in

Push slide into airlock and close the airlock all the way. **NB:** Push key LOCK (3.24), disengage airlock rod, slide it in and turn it into horizontal position (three o'clock); the airlock is evacuated. **Wait until the lamp in key LOCK IN (3.3) goes on;** ^{off screw 4/21/06} only then continue to turn the rod and push it in all the way in the guide track. The airlock rod springs back which uncouples the cartridge.

Chapter 15: Low magnifications 150x - 1100x

Condenser almost as far as right-hand stop. Withdraw the contrast aperture, change to magnification range I, focus with P1 potentiometer FOCUS (4.9) and insert selector aperture for contrast enhancement. Correct astigmatism with P1 stigmator (4.15).



Chapter 16: HC mode adjustment

Switch on instrument and make adjustments as described in Chapter 3.0.

Lock in a specimen mounted either in a short standard or a lifting cartridge.

Bring a specimen in a lifting cartridge to end position manually or with the motor drive.

Set mode switch (4.10) to HC, magnification to 3000x.

Insert contrast aperture $180\mu\text{m}$ (1.51) and center it on the large fluorescent screen. The contrast apertures $90\mu\text{m}$, $60\mu\text{m}$ and $30\mu\text{m}$ can be used at higher magnifications. The image should not be cut off.

The correction of astigmatism is different in the modes HC and HM. When changing between the modes HC and HM the astigmatism must always be corrected with the stigmator potentiometer at highest possible magnification.

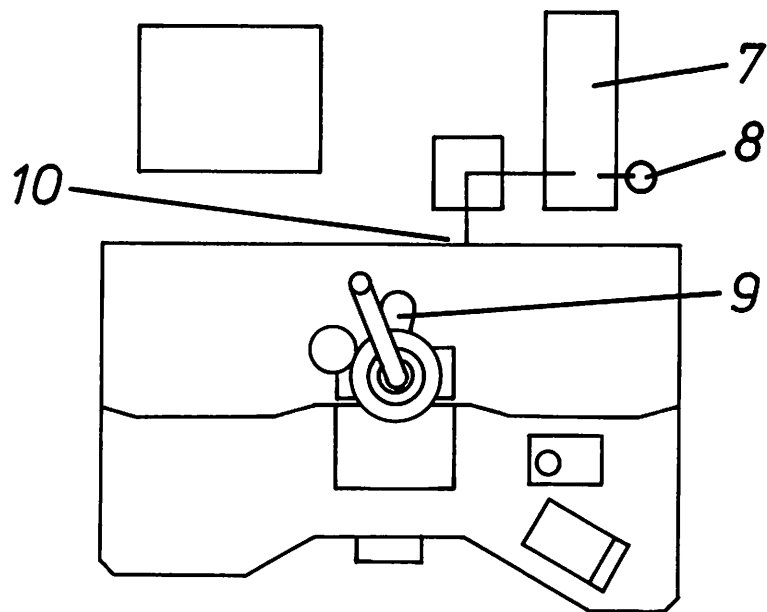
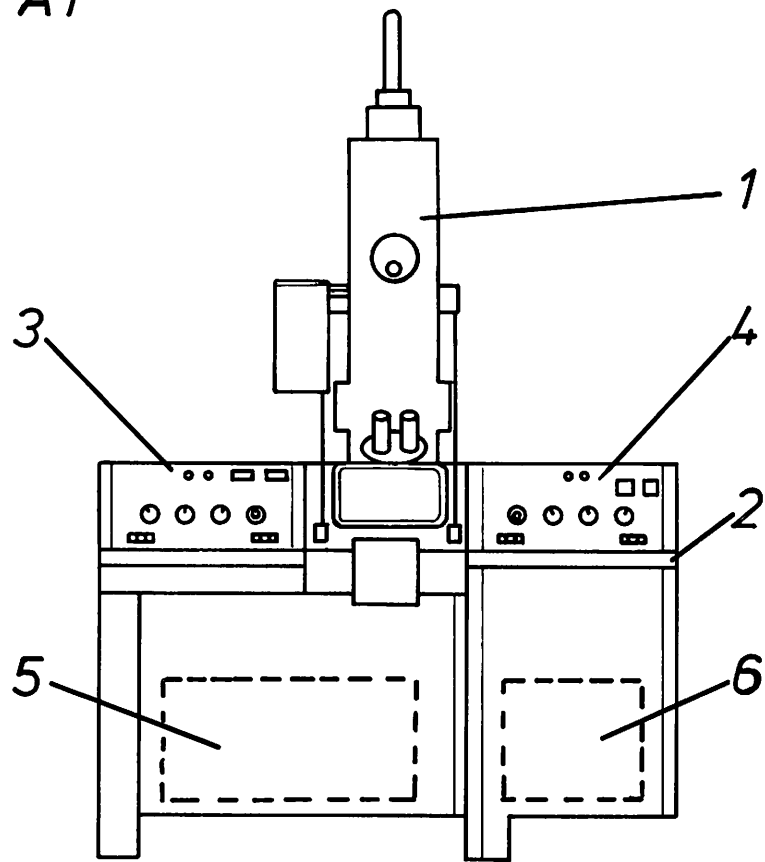
Chapter 17: Instrument switch-off

Turn condenser clockwise, magnification 3000x, switch off filament and high voltage and close valve V 3. Set key switch to position 0.

4.0 Description of instrument

Chapter		Page
1	Functional groups	4.1
2	Electron-optical column with high-vacuum pump system	4.1
3	Electron-optical column, description of main and subassemblies	4.2
4	Imaging modes/beam paths	4.9
5	Vacuum system	4.16
6	Instrument table	4.17
7	Control panels	4.18
8	High-voltage unit	4.23
9	Power supply	4.24
10.	Fuses	4.24
11	Closed-loop cooling system	4.25

A1



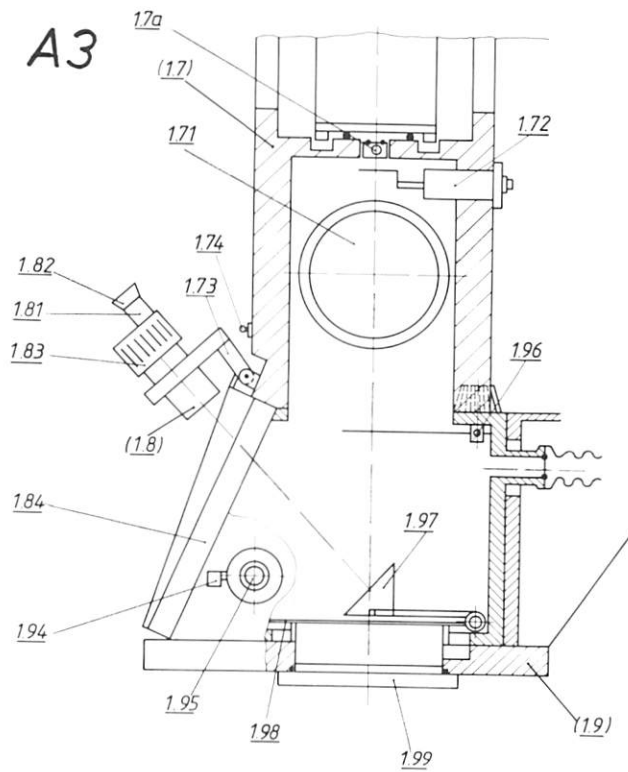
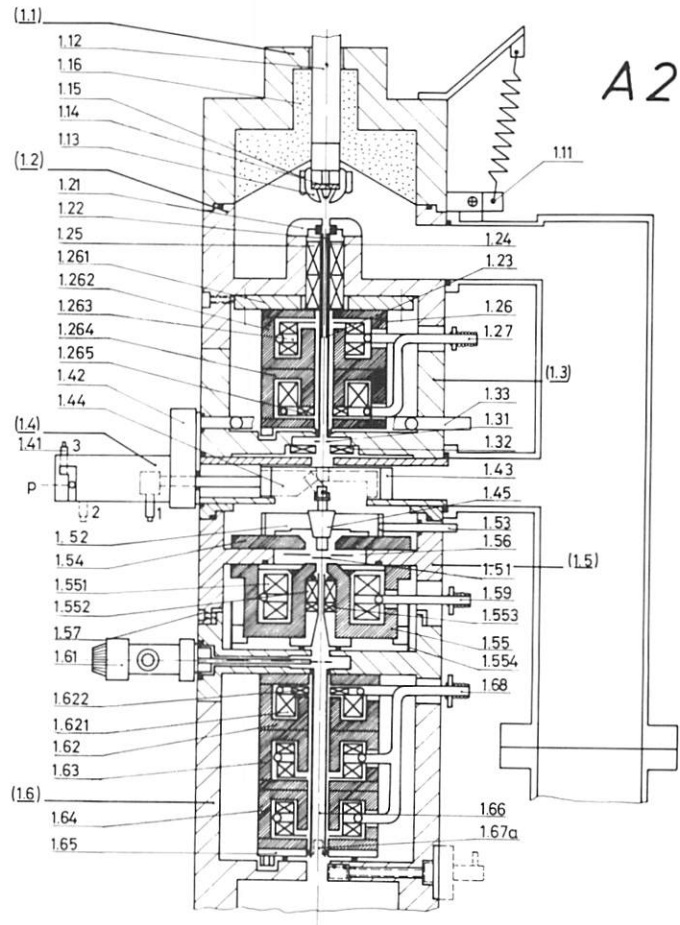
4.1 Functional groups (Fig. 1)

- (1) Electron-optical column
- (2) Instrument table
- (3) Left control panel
- (4) Right control panel
- (5) High-voltage unit
- (6) Power supply
- (7) Rotary pump
- (8) Oil mist filter
- (9) High-vacuum unit
- (10) Closed-loop cooling system

4.2 Electron-optical column with high-vacuum pump system

The electron-optical column (1) is rigidly connected with the high-vacuum pump system (9) and mounted on the instrument table (2) as enclosed unit.

The pre-vacuum system comprising rotary pump (7) and oil mist filter (8) is accommodated behind the instrument table.

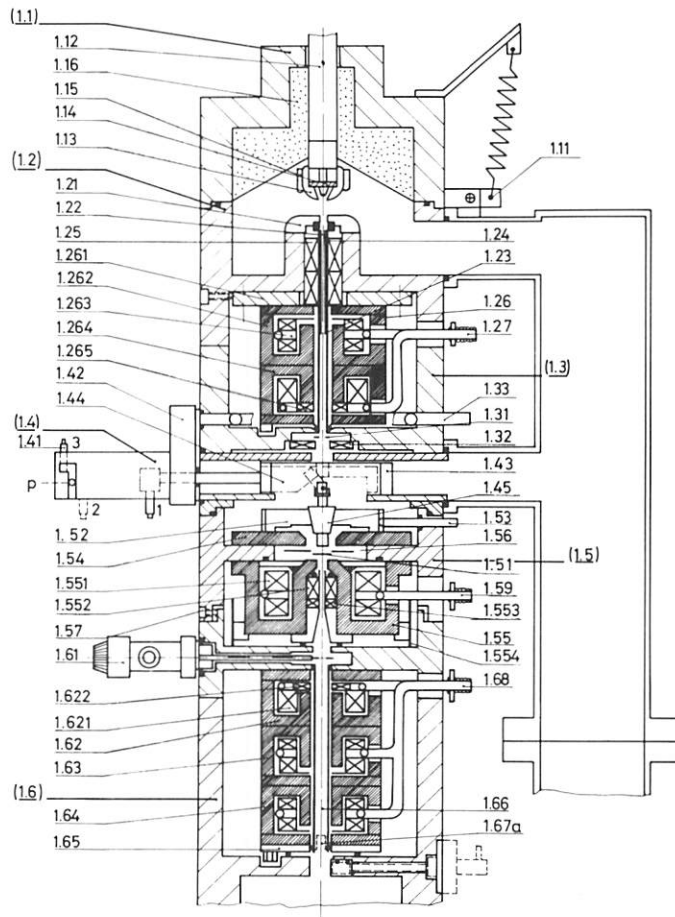


4.3 Electron-optical column (1) (Fig. 2/3)

Description of main assemblies

- (1.1) Cathode head with cathode insulator, filament with Wehnelt cylinder and high-voltage plug.
- (1.2) Anode housing with electromagnetic beam alignment system and 2-lens (electromagnetic) condenser system with electromagnetic stigmator.
- (1.3) Airlock housing with condenser aperture, electromagnetic deflecting system for MDF (Minimum-Dose Focusing) mode, mounting port and pre-vacuum connection for specimen airlock.
- (1.4) Specimen airlock with control tube and cartridge insert for lock-in/out of specimen cartridges.
- (1.5) Objective lens: high-performance, factory-adjusted objective lens with specimen stage for specimen shift, internal cooling plates (anticontaminator), contrast aperture, electromagnetic stigmator and deflecting system for MDF mode.
- (1.6) Projector lens system: 3-lens electromagnetic, factory-aligned projector lens system with electromagnetic stigmator.
- (1.7) Shutter housing: intermediate tube with electromagnetic photographic shutter and mounting ports for accessories (e.g. 35mm or CCD camera).
- (1.8) Viewing microscope: binocular viewing microscope for observation of the fluorescent screen.
- (1.9) Viewing chamber with window for observation of the fluorescent-screen image, fluorescent screens for observation of the image, port and base plate to mount accessories, e.g. photography system.

A2



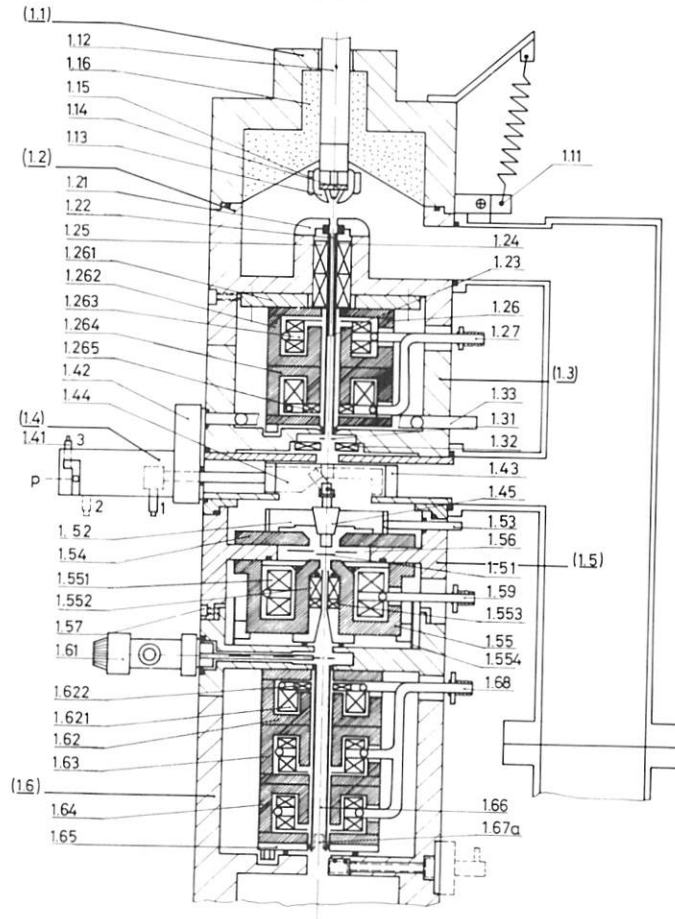
4.3.1 Electron-optical column (Fig. 2)**Description of subassemblies****(1.1) Cathode head**

- (1.11)** Spring hinge to hinge the cathode head back for filament exchange after ventilation of the column.
- (1.12)** High-voltage plug (oil-free) and high-voltage cable
- (1.13)** Wehnelt cylinder
- (1.14)** Filament holder with tungsten filament, which is aligned in the Wehnelt cylinder.
- (1.15)** Retaining ring for Wehnelt cylinder
- (1.16)** Cathode insulator providing for insulation between high-voltage and earth potentials

(1.2) Anode housing

- (1.21)** Screw-in anode, counterelectrode of Wehnelt/filament system
- (1.22)** Two-part cleaning tube can be pulled out when the anode (1.21) is unscrewed, and provides access for cleaning of
- (1.23)** built-in C1 aperture (stray electron aperture behind the C1 lens).
- (1.24)** Rigidly mounted, through-going vacuum tube
- (1.25)** Two-stage electromagnetic beam alignment system, for alignment of electron beam and optical axis.
- (1.26)** Factory-aligned double condenser
- (1.261)** Base plate carrying the double condenser; the entire condenser unit is movable for alignment with adjusting screws (S).
- (1.262)** First condenser lens C1, permanently energized, with water-cooled coil and
- (1.263)** sensor to monitor the cooling-water temperature.

A 2

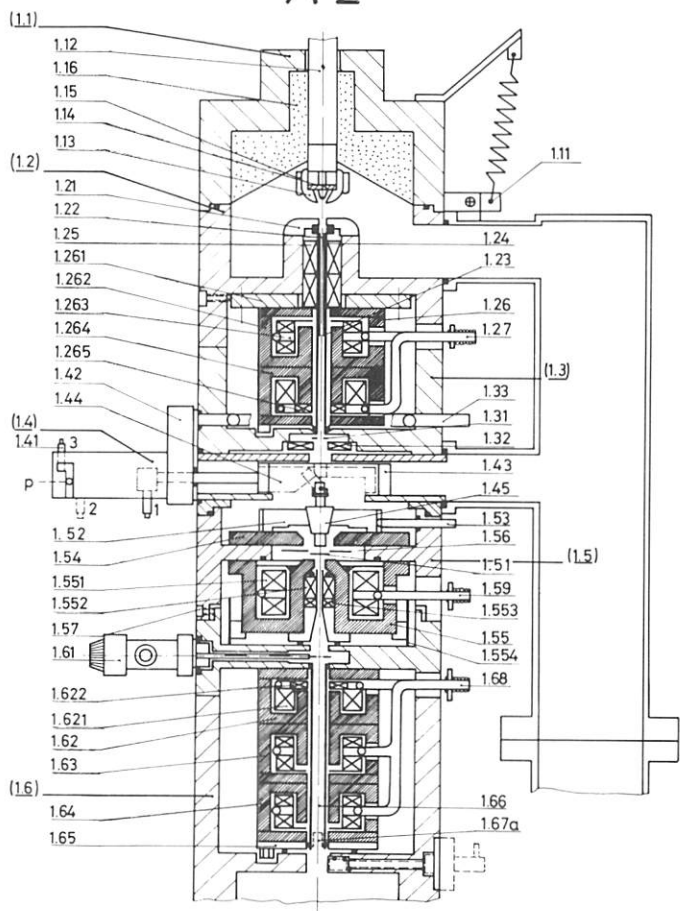


- (1.264) Second condenser lens C2 with water-cooled coil; it forms an image of the $3\mu\text{m}$ dia. illuminated area in the specimen plane; dia. of max. illuminated area $>2\text{mm}$.
- (1.265) Electromagnetic K2 stigmator to compensate the astigmatism of illumination
- (1.27) Condenser system cooling-water connection.

- (1.3) Airlock housing
- (1.31) Condenser aperture: 3 apertures of $400\mu\text{m}$, $200\mu\text{m}$ and $100\mu\text{m}$ dia., which are selected and shifted with the aperture drive.
- (1.32) Upper MDF deflecting system: in MDF (Minimum Dose Focusing) mode it shifts the electron beam to a spot approx. $5\mu\text{m}$ adjacent to the objective lens axis.
- (1.33) Vacuum connection: pump line for specimen airlock

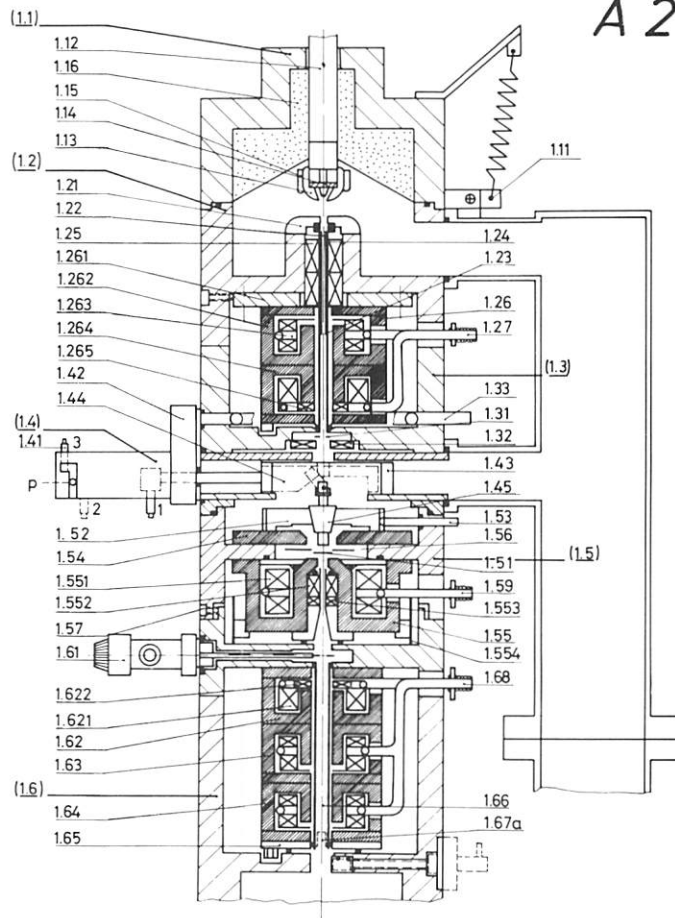
- (1.4) Specimen airlock
- (1.41) Lock-in rod:
 - Position 1: specimen cartridge in stage
 - Position 2: specimen cartridge still in high vacuum (standby)
 - Position 3: airlock can be opened
 - Position P: rod (1.41) horizontal, airlock is pre-evacuated.
- (1.42) Knurled knob: when turned anticlockwise the airlock chamber is ventilated and opened (possible only if (1.41) is in position 3).
- (1.43) Internal guide tube: closes the column (positions P, 3).
- (1.44) Cartridge holder: secures and transports the specimen cartridge.
- (1.45) Specimen cartridge: carries the specimen and is inserted in the stage in normal position (1).

A 2

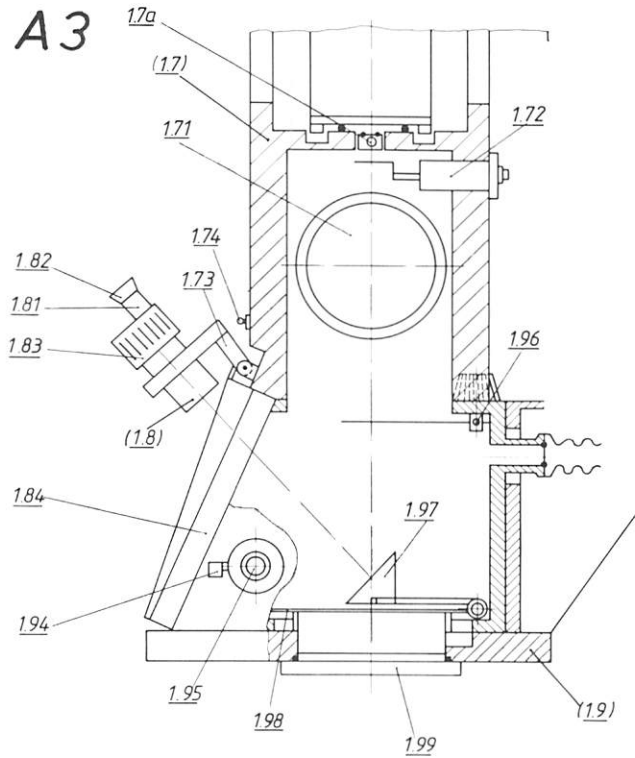


- (1.5) Objective
Factory-aligned high-performance objective lens
Electron-optical data:
f = 2.6mm (focal length)
Cs= 2.2mm (spherical aberration constant)
Cc= 1.7mm (chromatic aberration constant)
- (1.51) Contrast aperture: 3 thin-film apertures, selected and centered by the contrast aperture drive; aperture diameters: 180 μ m, 90 μ m, 60/30 μ m (7 holes)
- (1.52) Specimen stage
- (1.53) Specimen shift moving the stage on
- (1.54) upper pole plate \pm 1mm in X and Y
- (1.55) Lens yoke (with pole piece) carrying
- (1.551) water-cooled lens coil, thermally isolated from (1.55).
- (1.552) Electromagnetic objective lens stigmator, electrically centrable to objective lens axis.
Integrated in objective lens stigmator:
- (1.553) lower deflecting system for MDF which brings back on the imaging axis the beam deflected by (1.32).
- (1.554) mu-metal cylinder screening against electromagnetic strayfields.
- (1.56) Anticontaminator, internal cooling plates provided for mounting of the anticontaminator (accessory).
- (1.57) The upper half of the column can be shifted relative to the fixed projector lens system and aligned with the screws (S) when the 3 screws are loosened which connect the column.

A 2



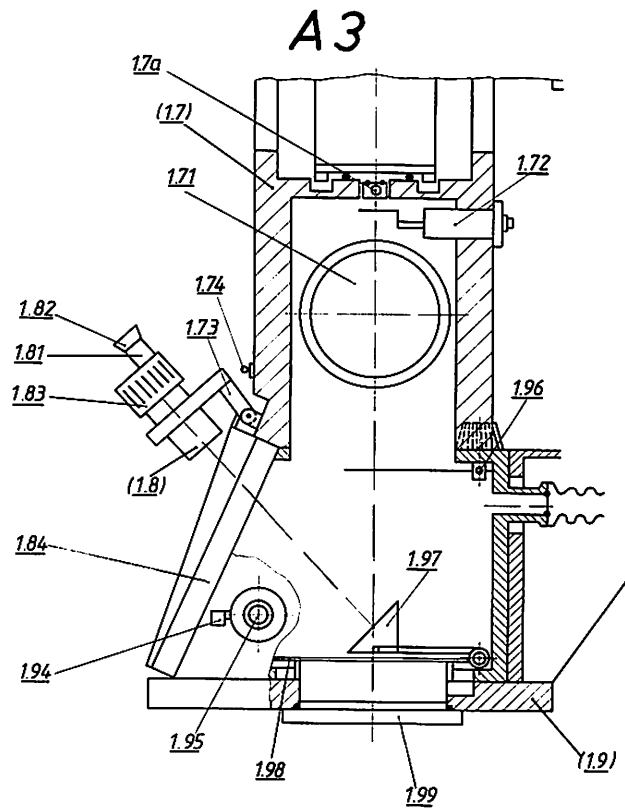
A 3



- (1.58) Blind flanges (not shown): openings for alignment drives or to mount accessories such as goniometer, anticontaminator, etc.
- (1.59) Objective lens cooling-water connection

- (1.6) Projector lens system
comprising 3 factory-aligned projector lenses:
 - (1.61) Sector aperture: 3 apertures of $400\mu\text{m}$, $200\mu\text{m}$ and $50\mu\text{m}$, selectable with aperture drive.
 - (1.62) First projector lens (P1): lens current automatically adjusted to changed magnifications (no loss of focus).
 - (1.621) Water-cooled coil thermally isolated against iron jacket.
 - (1.622) Electromagnetic P1 stigmator
 - (1.63) Second projector lens (P2): lens current automatically adjusted to changed magnifications, water-cooled coil.
 - (1.64) Third projector lens (P3): lens permanently energized, water-cooled coil.
 - (1.65) Sealing plate
 - (1.66) Through-going vacuum tube from projector lens housing ring to sealing plate (1.65).
 - (1.67a) Throttle for differential pump system acting as pressure stage aperture ($200\mu\text{m}$ fixed aperture).
 - (1.68) Water connection for projector lens coils

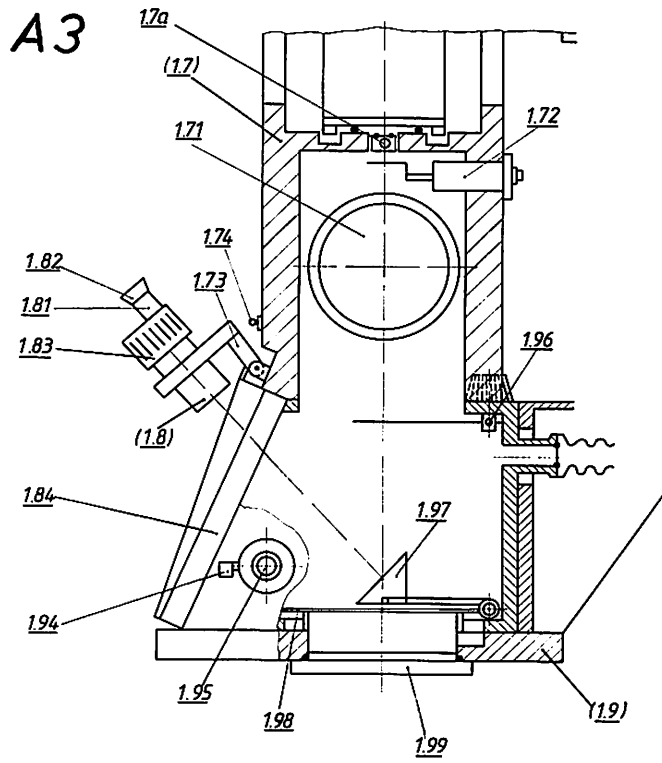
- (1.7) Shutter housing (Fig. 3)
 - (1.7a) Valve V 3: manual valve to separate vacuum chambers in the column.
 - (1.71) Flanges, lateral ports for accessories such as 35mm camera, sector diaphragm, CCD camera.



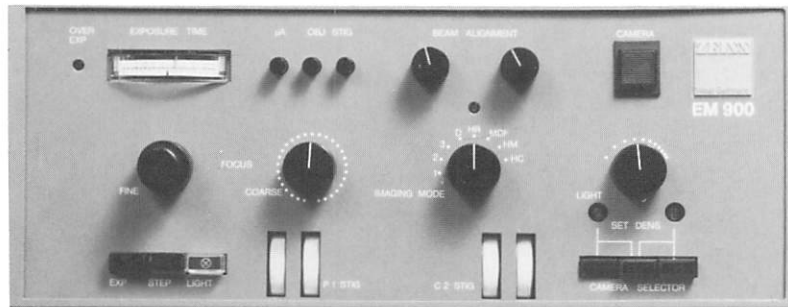
- (1.72) Photographic shutter: Electromagnetic, controlled by automatic exposure control.
- (1.73) Viewing microscope mount which allows moving the viewing microscope horizontally across the entire focusing fluorescent screen and swinging the microscope up.
- (1.74) Knob which locks the viewing microscope in swung-up position.

- (1.8) Viewing microscope
Binocular viewing microscope 9x, focusable on small fluorescent screen.
- (1.81) Individually adjustable eyepieces
- (1.82) Eyecups (folding eyecups for spectacle wearers)
- (1.83) PD adjustment by turning the tubes
- (1.84) Window, removable for exchange of fluorescent screen.

- (1.9) Viewing chamber
- (1.91) Specimen drive control (PC version only); small diameter for fast motion, large diameter for precision movement of specimen.
- (1.92) Specimen position display (PC version only): displays for each index line (\wedge 1 revolution) a specimen shift of $50\mu\text{m}$; if the display is 0 the specimen stage is in middle position.
- (1.93) Socket for desk lamp



- (1.94) Lever for fluorescent screen to remove both screens from the beam path. The large fluorescent screen remains swung up for photography with the sheet film camera. Lever (1.94) engages in horizontal (normal) and vertical (exposure) positions.
- (1.95) Knob to swing out the focusing fluorescent screen (1.97) for observation of the large fluorescent screen (1.98).
- (1.96) Swing-in beam stop to block the zero beam in diffraction mode (suitable as pointer for specimen features).
- (1.97) Focusing fluorescent screen serving also as measuring surface for the automatic exposure control.
- (1.98) Large fluorescent screen with outlines of the photographic format of the sheet film camera.
- (1.99) Blind flange closing the port for sheet film or TFP camera.



4.4 Imaging modes and beam paths

(see Figs. 4a-e)

Any of the following imaging modes can be selected with the image mode switch on the right panel:

HR High Resolution
 HM High Magnification (400,000x)
 D Diffraction
 MDF Minimum Dose Focusing
 HC High Contrast

1 }
 2 } alignment checks
 3 }

15 steps (divided in 3 ranges) are selectable with the magnification selector in HM and HC modes:

HR

Range I:	150x- 1100x	(step 1-5)
Range II:	3000x- 20000x	(step 6-10)
Range III:	30000x-250000x	(step 11-15)

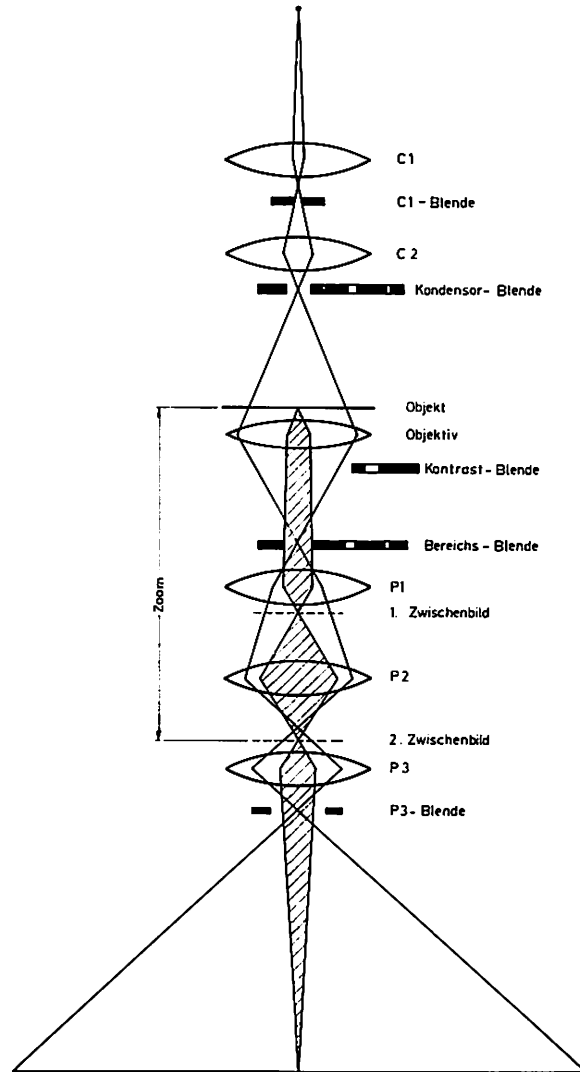
HC

Range I:	150x- 1100x	(step 1-5)
Range II:	1200x- 8000x	(step 6-10)
Range III:	12000x-100000x	(step 11-15)

The beam paths for the magnification ranges I, II, III in HR and HC modes and for the D and MDF modes are shown in Figs. 4a-e. Modes 1, 2, 3 include special lens energizations to optimize and check the instrument alignment. They are not explained here.

I

M: 150 X - 1100 X



HR and HC modes

4.4.1 Magnification range I (Fig. 4a)

M	150x - 1100x (low magnifications)
C1 lens	Permanently highly energized (fixed)
C2 lens	Variable, so that the crossover image lies in the condenser aperture plane
Condenser aperture	It remains in the beam path. The specimen illumination is divergent over an area of max. 2mm dia.!
Specimen	The same position as at medium and high magnifications.
Objective lens	Moderately energized (fixed). It images the crossover image from the condenser aperture plane into the intermediate image aperture plane.
Contrast aperture	It must be retracted to prevent cutoff of the image.
Intermediate image aperture	It is optimally centered and acts as contrast aperture of the P1 lens without cutting off the image (actual objective lens).
P1 lens	With the moderately energized objective lens it forms an image of the specimen (with distortion correction) in the first intermediate image plane before the P2 lens.
P2 lens	It magnifies the first intermediate image in 5 steps and images it in the fixed second intermediate image plane before the P3 lens.
P3 lens	It is highly energized (fixed), and magnifies the second intermediate image in the plane of the fluorescent screen.

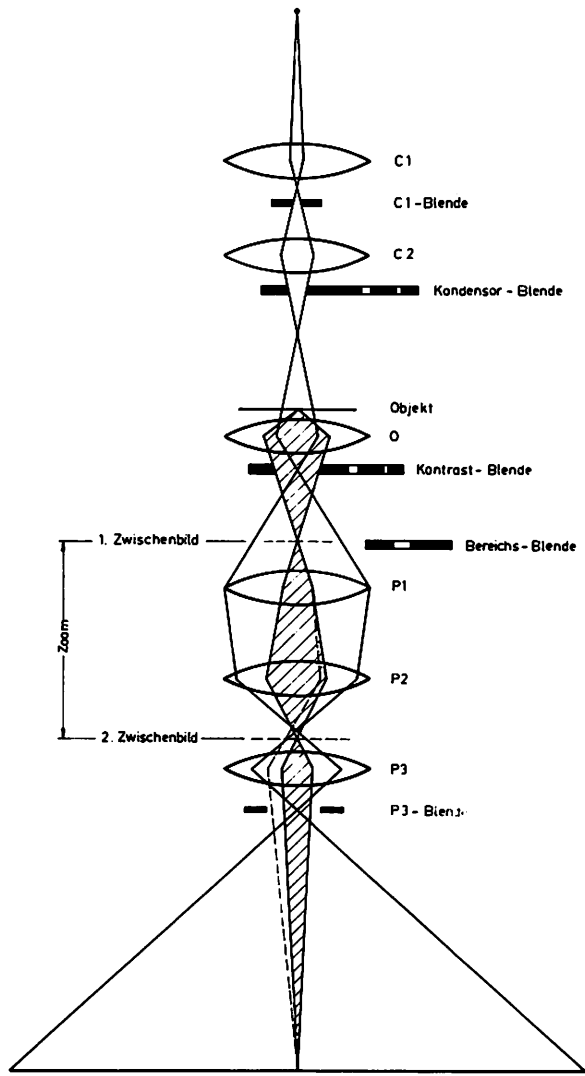
Lens adjustment

1. Fix-focus zoom system

The currents of the P1 and P2 lenses are programmed so that the specimen is always imaged exactly in the second intermediate image plane when the magnification is changed between 1100x and 150x, provided focusing is made at 1100x (P1).

II

M : 3000 X - 20 000 X
 ---- chrom. Kompensation



2. Distortion correction

The parfocality of objective lens and P1 lens guarantees optimized correction of image distortion.

The high-contrast effect in magnification range I is obtained by the low imaging aperture ($< 10\text{-}3\text{rad}$) and the exceptionally low illuminating aperture ($< 10\text{-}6\text{rad}$).

4.4.2 Magnification range II (Fig. 4b)

M 3000x - 20000x (HR)
 1200x - 8000x (HC)

C1 lens	Permanently highly energized (fixed)
C2 lens	Depending on the magnification divergently variable (overfocus) for total illumination of the image.
Condenser aperture	400 μm , 200 μm , 100 μm dia. selectable aperture
Specimen	Same position as in magnification range I.
Objective lens	Highly energized. Moderately energized in high-resolution HC mode. It images the specimen in the intermediate image aperture plane (1st intermediate image).
Contrast aperture	It is in the beam path and defines the imaging aperture.
P1 lens	The 1st intermediate image is imaged in the
P2 lens	2nd intermediate image plane during magnification change by means of suitable lens adjustment.
P3 lens	It is permanently highly energized (fixed) and images the 2nd intermediate image in the fluorescent screen plane.

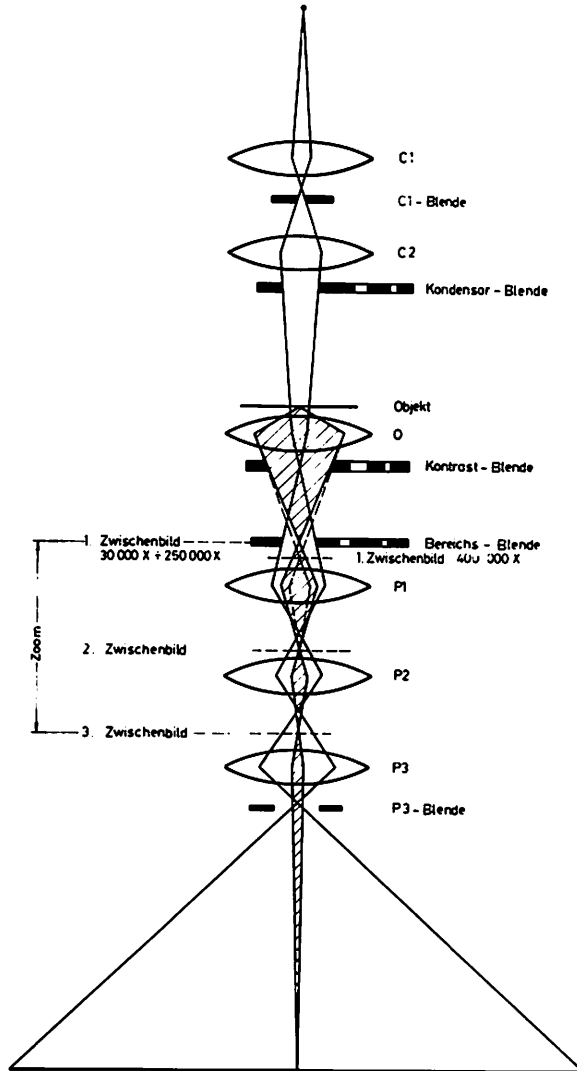
Lens adjustment

1. Fix-focus zoom system

By suitable adjustment of the P1/P2 lenses the fixed 1st intermediate image (the objective lens is varied only for focusing and then remains fixed) is imaged exactly in the fixed 2nd intermediate image when the magnification is changed in the range 20000x to 3000x.

III

M : 30 000 X - 250 000 X
 --- 400 000 X



2. Compensation of chromatic and spherical aberrations

The parfocality of the P1/P2/P3 lenses guarantees optimized compensation (broken beam path in Fig. 4b: electrons with energy loss).

3. Objective lens focusing

The focusing increment is automatically adjusted to the magnification:

M(HR)	20000x	12000x	7000x	4400x	3000x
M(HC)	8000x	4800x	2800x	1760x	1200x
f(nm)	120	240	480	480	960

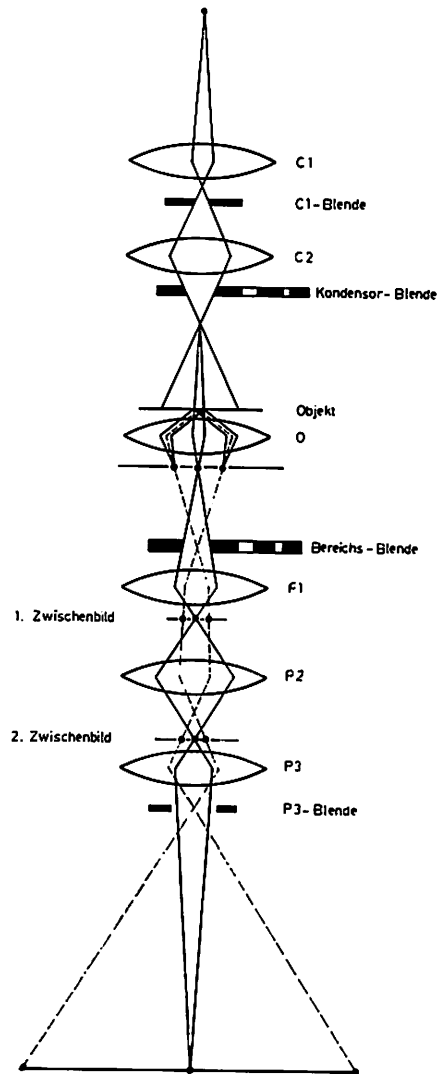
4.4.3 Magnification range III (Fig. 4c)

M 30000x - 250000x (HR)
12000x - 100000x (HC)

C1 lens	Permanently highly energized (fixed)
C2 lens	Variable; at high magnifications near minimum illuminated area of 3 μ m dia.
Condens- er aperture	Selectable diameter; 400 μ m dia. preferable at high magnification.
Specimen	Same position as in ranges I and II.
Objec- tive lens	Highly energized. Moderately energized in high-resolution HC mode. Imaging and focusing as in range II.
Contrast aperture	In the beam path; its diameter defines the imaging aperture
Inter- mediate image aperture	In the beam path; selectable diameter: 400 μ m, 200 μ m, 50 μ m
P1 lens	Forms real image of (fixed) 1st intermediate image in 2nd intermediate image before P2 lens.
P2 lens	Forms real image of 2nd intermediate image (variable position because of magnification change with P2) in (fixed) 3rd intermediate image before P3 lens.
P3 lens	Permanently highly energized (fixed); images 3rd intermediate image in final image plane (fluorescent screen, film).

Feinbereichsbeugung

C.L.: 380 mm - 2800 mm



Lens adjustment

1. Fix-focus zoom system

The adjustment of the lenses P1/P2 guarantees that the fixed objective lens image (1st intermediate image) is imaged exactly in the fixed 3rd intermediate image when the magnification is varied between 250000x and 30000x. The zoom magnification is valid for both magnification ranges III and II (starting from 250000x!) because the objective lens focusing is the same.

2. Objective-lens focusing

The focusing increment is automatically adjusted to the magnification:

M(HR)	250000x	140000x	85000x	50000x	30000x
M(HC)	100000x	56000x	34000x	20000x	12000x
f(nm)	15	15	30	60	120

D mode

4.4.4 Diffraction (Fig. 4d)

Camera

length L 380mm to 2800mm

C1 lens Permanently highly energized (fixed)

C2 lens Differently energized, depending on the type of diffraction:
 α Selected area (SA) diffraction: wide specimen area illuminated.
 β Microbeam diffraction: 3 μ m spot focused in the specimen.

Condenser aperture Diameter selectable for matching to the type of diffraction:
 α SA diffraction: any diameter
 β Microbeam diffraction: 100 μ m dia. because of the illuminating aperture.

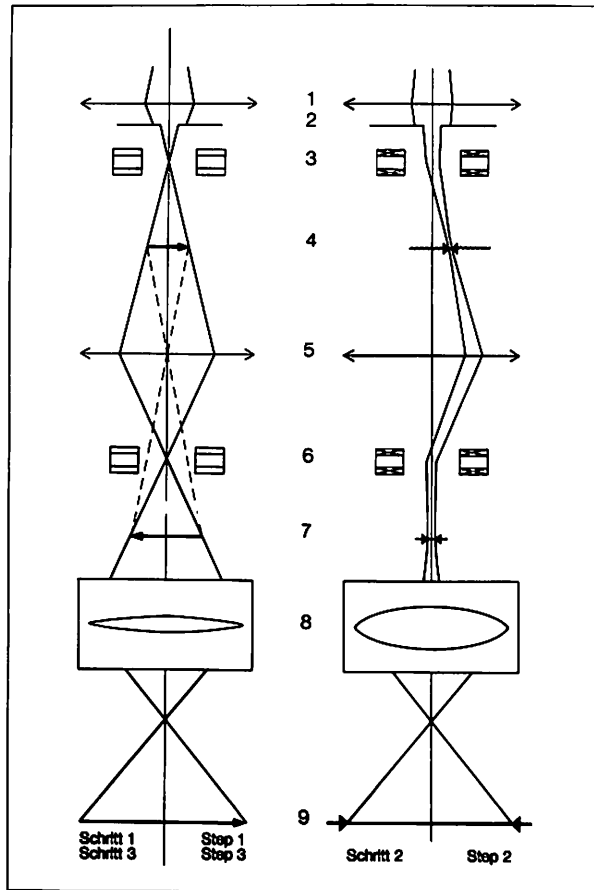
Specimen Same position as in ranges I and II.

Objective lens Same focusing as in ranges II/III.

Contrast aperture Retracted from the beam path.
 If not, cutoff with higher diffraction angles.

A 4e

EM 109 Strahlengänge für MDF
EM 109 Beam paths for MDF



- 1 Kondensator 2
- 2 Kondensatorblende
- 3 Oberes Ablenkensystem
- 4 Objektebene, „Bild“ des Cross-over (rechts)
- 5 Objektiv
- 6 Unteres Ablenkensystem
- 7 Zwischenbildebene
- 8 Projektivsystem
- 9 Endbild

- 1 Condenser 2
- 2 Condenser aperture
- 3 Upper deflecting system
- 4 Specimen plane, cross-over "image" (right)
- 5 Objective lens
- 6 Lower deflecting system
- 7 Intermediate image plane
- 8 Projector lens system
- 9 Final image

Inter- mediate image aperture	Diameter selectable for matching to the type of diffraction α SA diffraction: diameter defines selected specimen area			
	aperture dia. (μm)	400	200	50
	specimen area (μm)	13.3	6.6	1.6
	β aperture dia. at least $200\mu\text{m}$			
P1 lens	Images the diffraction pattern in the rear objective lens focal plane in the intermediate image plane before the P2 lens.			
P2/P3 lenses	As in magnification range III.			

Lens adjustment

1. Fix-focus zoom system

The adjustment of the P1/P2 lenses guarantees that when changing the magnification the diffraction image is always imaged exactly in the fixed intermediate image plane before the P3 lens, provided focusing is made at maximum diffraction length (step 5).

2. Camera lengths

Step	1	2	3	4	5
L(mm)	380	640	1020	1780	2800

4.4.5 MDF mode

Minimum Dose Focusing (Fig. 4e)

The method protects the specimen while the image is recorded by focusing on a spot adjacent to the specimen area selected for photography, using the zoom magnification of ranges III/II.

C1 lens Highly energized (fixed)

C2 lens Images the minimum spot in the specimen plane

Condenser aperture Diameter selectable; preferably $400\mu\text{m}$ dia.

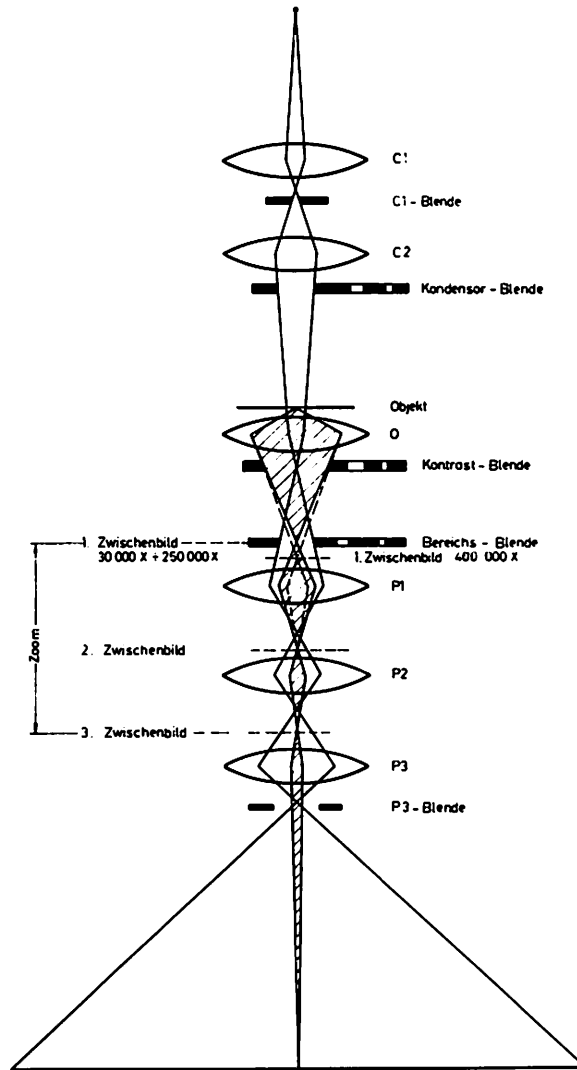
Upper MDF deflecting system Electromagnetic deflecting system shifting the minimum spot approx. $5\mu\text{m}$ adjacent to the objective lens axis.

Specimen Spot selected for focusing (with specimen damage) $5\mu\text{m}$ adjacent to the objective lens axis.

Objective lens Focusing and imaging as in ranges II/III.

III

M : 30 000 X - 250 000 X
 --- 400 000 X



Contrast aperture	As in ranges III/II.
-------------------	----------------------

Lower MDF deflecting system	Electromagnetic deflecting system shifting the $5\mu\text{m}$ deflected illuminated specimen area back to the P1 imaging axis.
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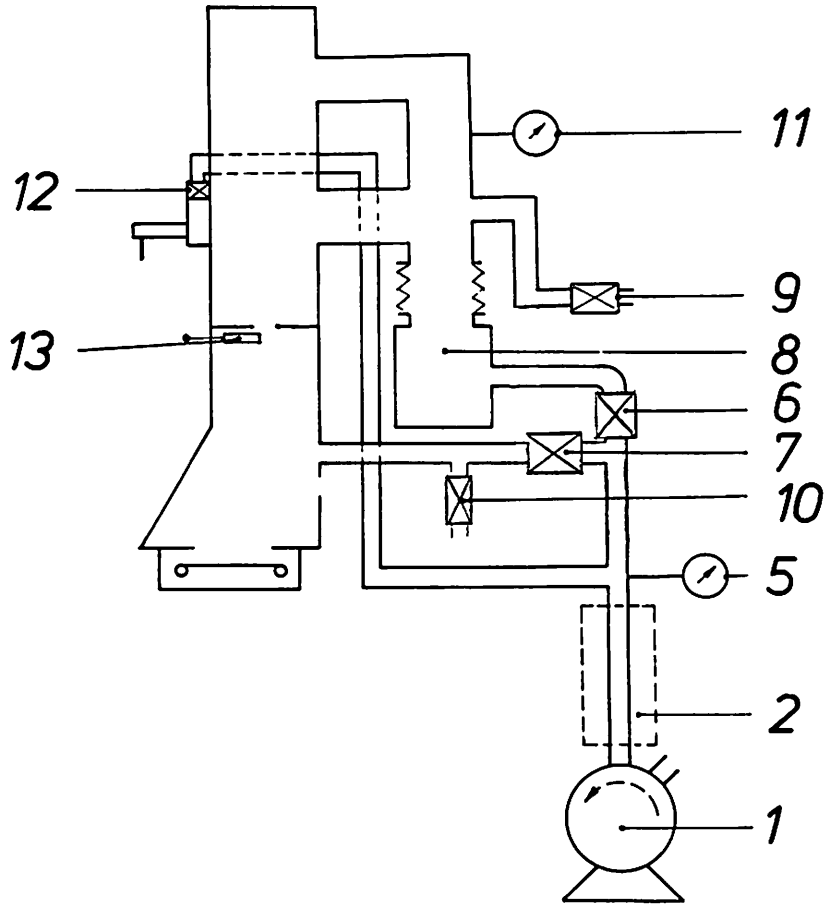
P1/P2/P3 lenses	140000x magnification (range III, step 4)
-----------------	---

Lens adjustment MDF

Spot shift, C2 minimum spot, and 140000x magnification (P1/P2) are programmed. When the specimen is focused and you change to N, the fix-focus system guarantees that the focus is maintained in each magnification step of the ranges III/II at M 140000x.

4.4.6 HM mode

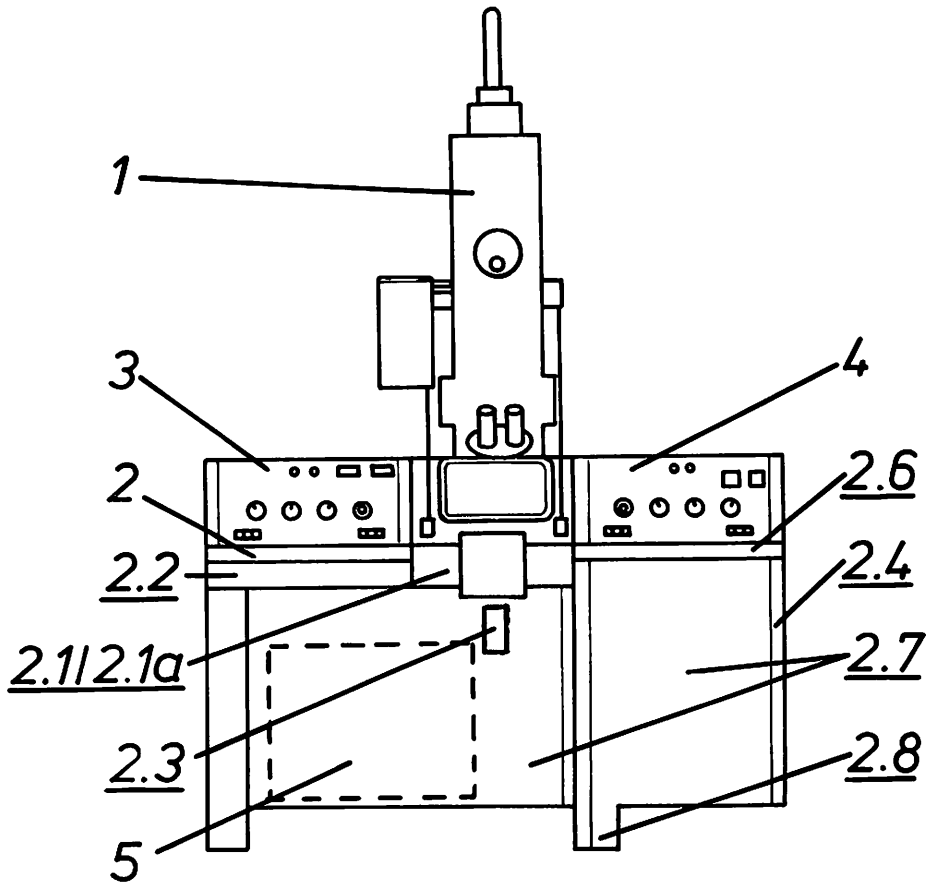
Highest magnification 400000x (Fig. 4c) for high-resolution observation on the fluorescent screen. Imaging mode as in magnification range III. Lens adjustment HM: effective only from magnification range III, but the P1 current is higher, the magnification increased due to lower objective lens current, and lower 1st intermediate image position.



4.5 Vacuum system (Fig. 5)

- 1 Rotary pump
 - 2 Adsorption trap (accessory)
 - 3 Anticontaminator (accessory)
 - 4 Oil mist filter (accessory)
 - 5 Pre-vacuum tube (Pirani system)
 - 6 Angle valve (turbomolecular pump)
 - 7 Angle valve (camera)
 - 8 Turbomolecular pump TPH 170
 - 9 Ventilating valve (column)
 - 10 Ventilating valve (camera)
 - 11 High-vacuum measuring tube (Penning system)
 - 12 Airlock valve
 - 13 Manual separating valve V3
- (for more information see Chapter 7)

A7

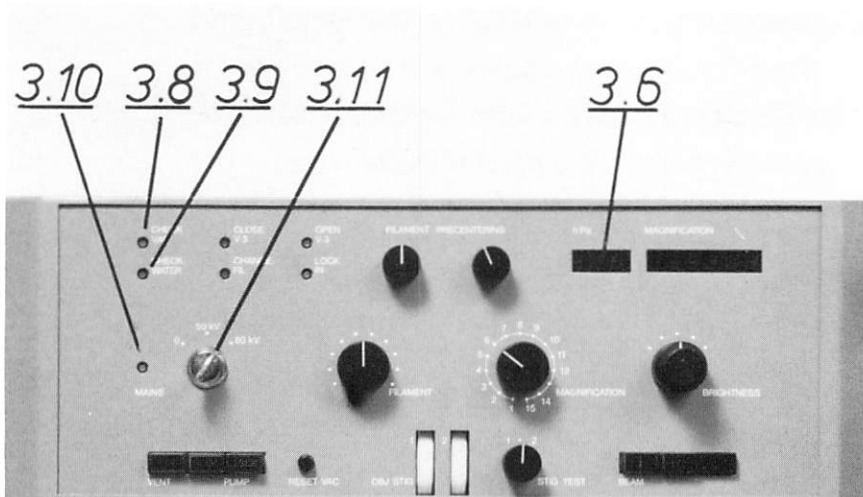
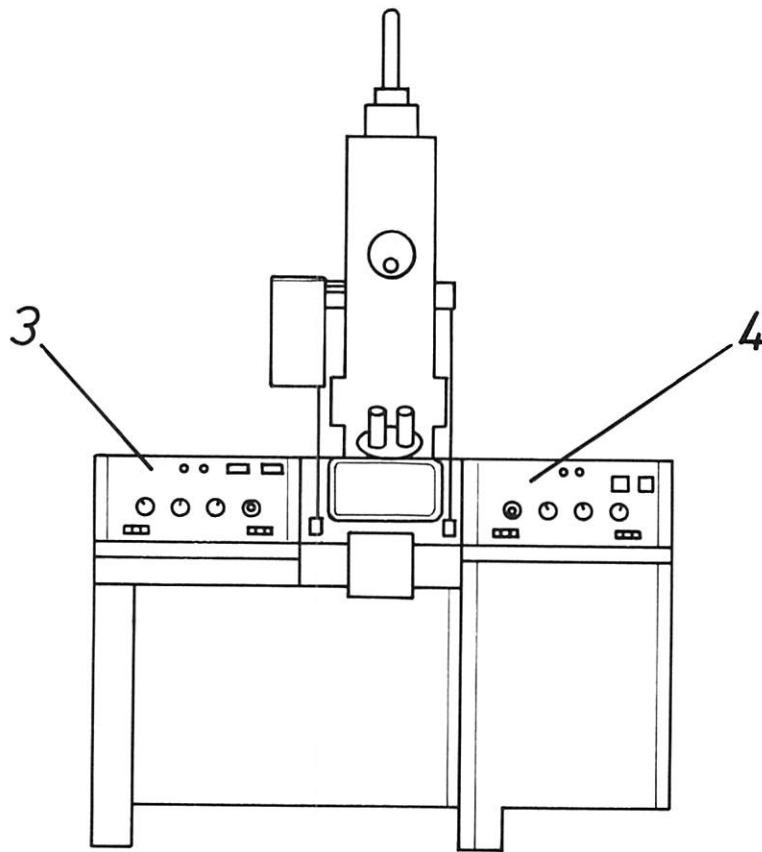


4.6 Instrument table (2)

The base which carries the instrument is a compact metal stand of high mechanical stability due to a T-shaped, load-bearing central part. The central T-shaped part (2.7) is rigidly screwed up with the table plate, and carries the vibration-resistant column/vacuum system assembly (1) and the camera system (2.1). Around the T-shaped central part the instrument base which acts as sheeting and support and accommodates at the side the power supply (6) with power input and at the back the high-voltage unit (5). The two control panels (3) and (4) are set up on the table plate.

Functional elements (Fig. 7)

- (2.1) Cover angle closing the port for
- (2.1a) Adapter for sheet film or TFP camera
- (2.2) Drawer with tools and utilities
- (2.3) Socket provided for electrical connection of adapter (2.1a)
- (2.4) Side wall, removable with suitable tool, for servicing of power supply (6)
- (2.5) Back wall, removable with suitable tool, for servicing of high-voltage unit (5)
- (2.6) Table plate carrying the control panels (3) and (4)
- (2.7) Central T-shaped part, the load-bearing construction of the instrument base, for transport of the instrument on a pallet, and for insertion of devices to lift off the instrument from the transport pallet at the place of installation.
- (2.8) Three-point support on vibration-resistant, height-adjustable legs.



4.7 Control panels (3) and (4)

They contain the control electronics.

4.7.1 Left panel (3): pump control and electronics for beam alignment and digital display.

4.7.2 Right panel (4): lens current control, lens current adjustment and automatic exposure control.

After removal of the sheet-metal hoods both panels can be detached from the table plate and swung back for servicing.

Operating controls

4.7.1 Left panel (3)

(3.11) Key switch for mode selection:

Position O: night service, key detachable to prevent unauthorized use of the instrument.

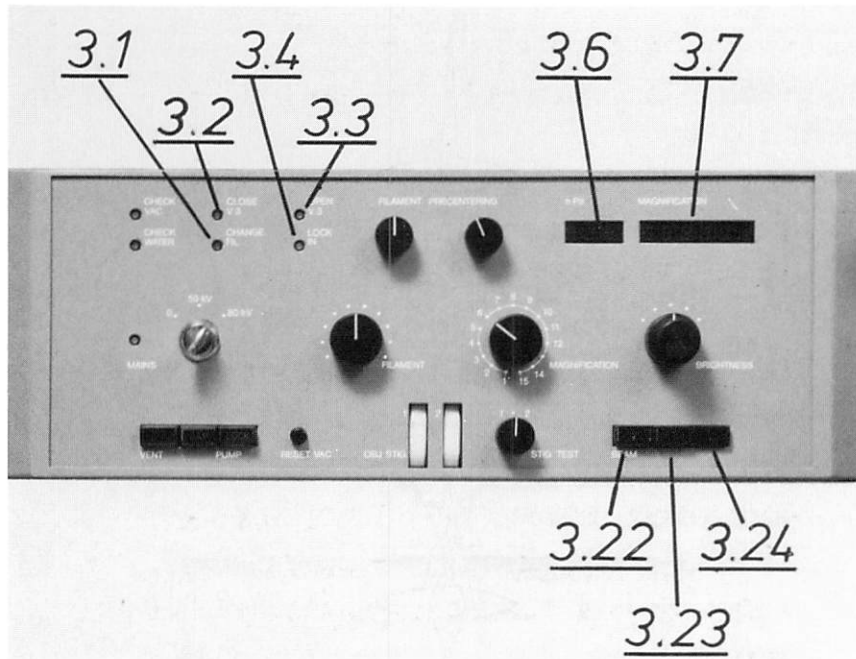
Position I: 50kV For operation of the instrument at 50 or 80kV.

Position II: 80kV

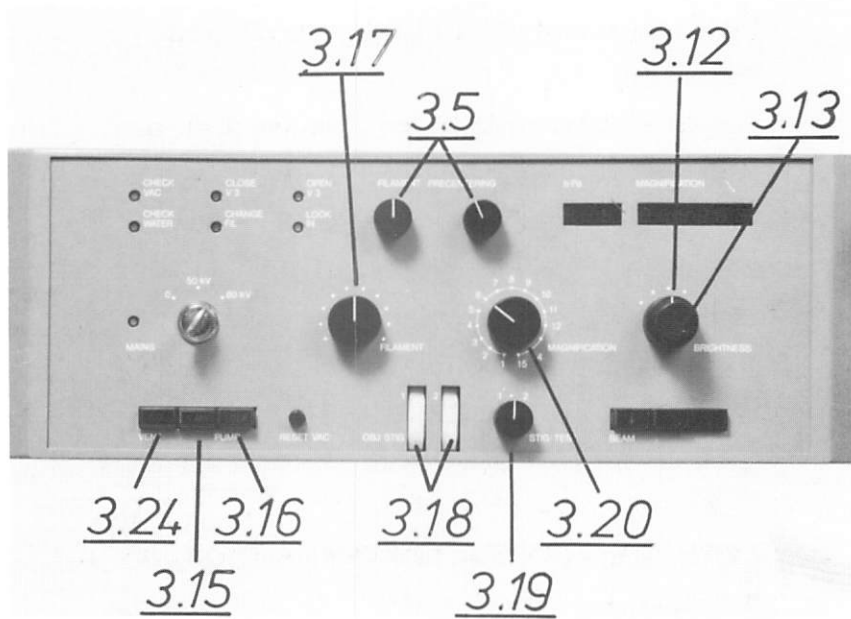
(3.10) Power signal lamp green: the instrument is supplied with 220V AC.

(3.9) CHECK WATER signal lamp red: water shortage; via 0 switch to 50kV/80kV.

(3.8) CHECK VAC signal lamp red: vacuum breakdown; error detection with coding of mode display (3.6).



- (3.1) CHANGE FIL signal lamp red: burnt-out filament must be exchanged.
- (3.3) LOCK IN signal lamp green: go-ahead for lock-in of specimen.
- (3.2) CLOSE V3 signal lamp red: if it flashes V3 is open because of insufficient vacuum in column or camera; shut valve V3.
- (3.4) OPEN V3 signal lamp green: go-ahead for V3; open V3 (another lamp available on V3).
- (3.22) High-voltage key green: high voltage ON when depressed.
- (3.23) Pushbutton filament: filament ON when depressed and OFF when released.
- (3.24) High-voltage key red: high voltage OFF when depressed.
- (3.6) Digital display (2 digits): high vacuum displayed in decimal powers, e.g. 5×10^{-6} mbar: 5 - 6 or 2×10^{-5} mbar: 2 - 5. No display and lamp (3.4) out: turbopump started and shortly before display value 1 - 3.
- (3.7) Digital display (6 digits): direct magnification display.



- (3.5) Two potentiometers: beam pre-centering X and Y (filament pre-centering, beam location and brightness optimization).
- (3.12) 5-step switch: beam current selection (brightness control).
- (3.13) Potentiometer: current control of condenser 2 (variation of illumination).
- (3.17) Potentiometer: control of filament heating current.
- (3.18) Two potentiometers: correction of objective lens stigmator.
- (3.19) Switch: check of objective lens stigmator setting.
- (3.20) 15-step switch: magnification change in 15 steps.
- (3.24) Pushbutton: pushed for ventilation or evacuation of column.
- (3.16) Key: pushed to start lock-in.
- (3.15) Pushbutton: pushed for ventilation or evacuation of camera.

Three sockets on the back wall of the left panel:

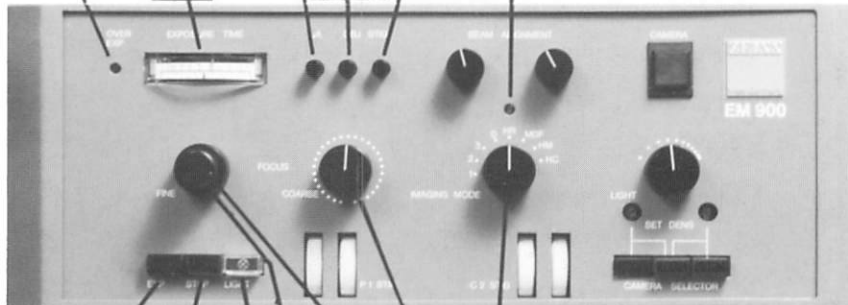
- (3.25) From top to bottom: gauge socket for high vacuum, free, gauge socket for pre-vacuum.

On the back wall of the right panel:

- (4.24) BNC gauge socket to measure the objective lens current with goniometer. Sockets (3.25) and (4.24) not shown.



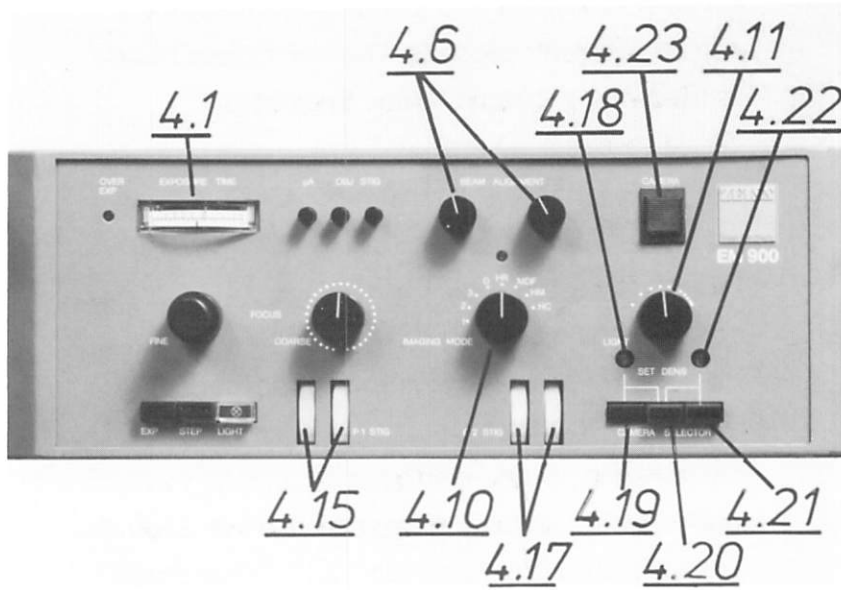
4.7 4.2 4.4 4.5 3.19



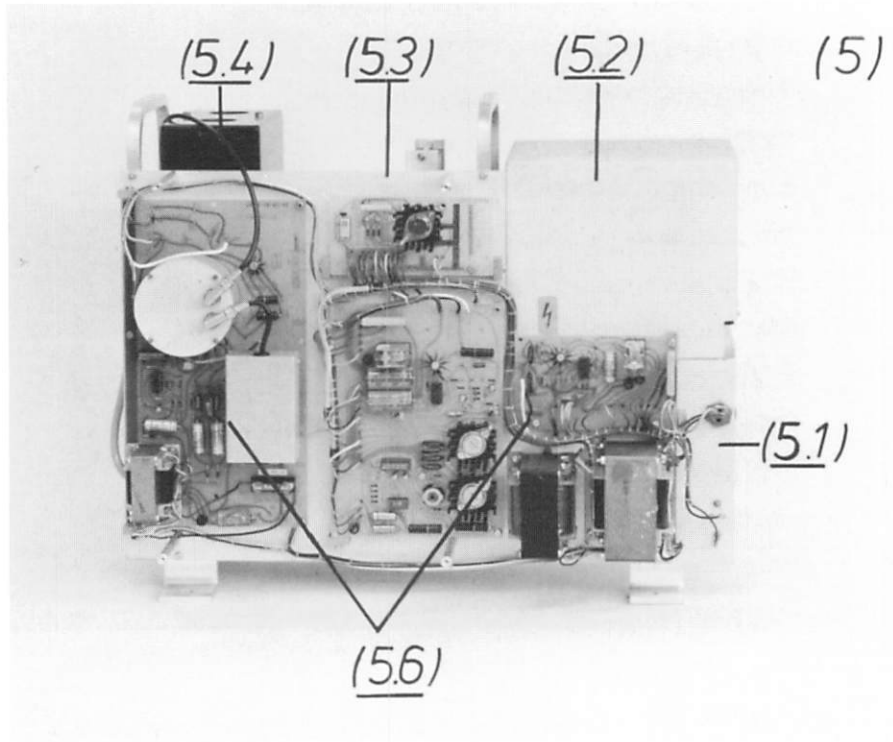
4.12 / 4.14 / 4.9 4.10
4.13 4.8 4.16

4.7.2 Right panel (4)

- (4.12)** Start key green: selected camera ready for exposure; depressing the key starts exposure cycle.
- (4.13)** Pushbutton: switches fine focusing steps of the objective lens at a ratio of 1:4.
- (4.14)** Pushbutton: switches desk lamp OFF and ruby light ON.
- (4.7)** Signal lamp red: displays overexposure.
- (4.1)** Display: The upper scale displays normally the exposure time in seconds. The lower scale serves to read off e.g. beam current, film density, objective lens stigmator.
- (4.8)** Continuous rotary knob: objective lens fine focusing (step size matched to the magnification).
- (4.9)** Potentiometer: P1 focusing, effective in magnification range I and diffraction mode.
- (4.16)** Step switch: objective lens coarse focusing.
- (4.2)** Key μA : when depressed the beam current is measured in μA and displayed on (4.1).
- (4.3)** Key +: when depressed the objective lens stigmator setting is measured, provided (3.19) is switched to either of the test points.
- (4.4)** Key -: must be depressed if (4.3) yields a negative deflection on (4.1).
- (4.5)** Signal lamp red: mode selector (4.10) is not in normal HR position if it lights.



- (4.10) Step switch: imaging mode selector with the positions HR (High Resolution), HC (High Contrast) MDF (Minimum Dose Focusing), HM (Highest Magnification 400000x), D (Diffraction), 1, 2, 3 (alignment checks).
- (4.6) Two potentiometers: precision alignment of beam.
- (4.15) Two potentiometers: P1 stigmator, correction of astigmatism in magnification range I and diffraction mode.
- (4.17) Two potentiometers: C2 stigmator, correction of astigmatism of illumination.
- (4.19) Pushbutton: depressed to select sheet film or TFP camera.
- (4.21) Pushbutton: depressed to select 35mm camera.
- (4.20) Key: depressed to check the density setting (4.18)/(4.22) on (4.1).
- (4.18) Potentiometer: density setting (screwdriver) for TFP camera ((4.20)/(4.21) depressed for a check).
- (4.11) Potentiometer: variation of desk lamp brightness.
- (4.23) Pushbutton: power switch for sheet film camera.



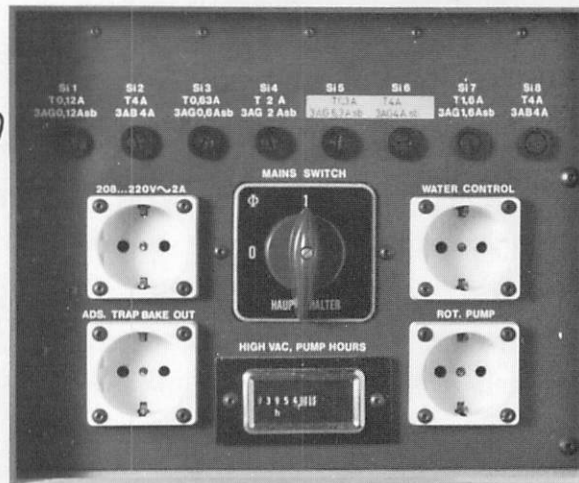
4.8 High-voltage unit (5)

It is accommodated at the back of the instrument base (2), and accessible for servicing after removal of the back wall.

- (5.1) High-voltage housing with components (cascade, feedback resistor and internal housing for cathode bias resistor and filament heating) for high-voltage generation according to the cascade multiplier principle. Filled with high-voltage-resistant insulating liquid.
- (5.2) Housing for converter to generate the primary high-frequency high voltage for the filament.
- (5.3) Insulating transformer for filament heating.
- (5.4) Housing with expansion tank for insulating liquid.
- (5.5) Dry high-voltage plug connection for high-voltage cable to cathode head (not shown).
- (5.6) Electronics for stabilization and control of high voltage, filament heating and beam current.

Kap. 4.10
6.8-6.15

Kap. 4.9
6.1-6.7



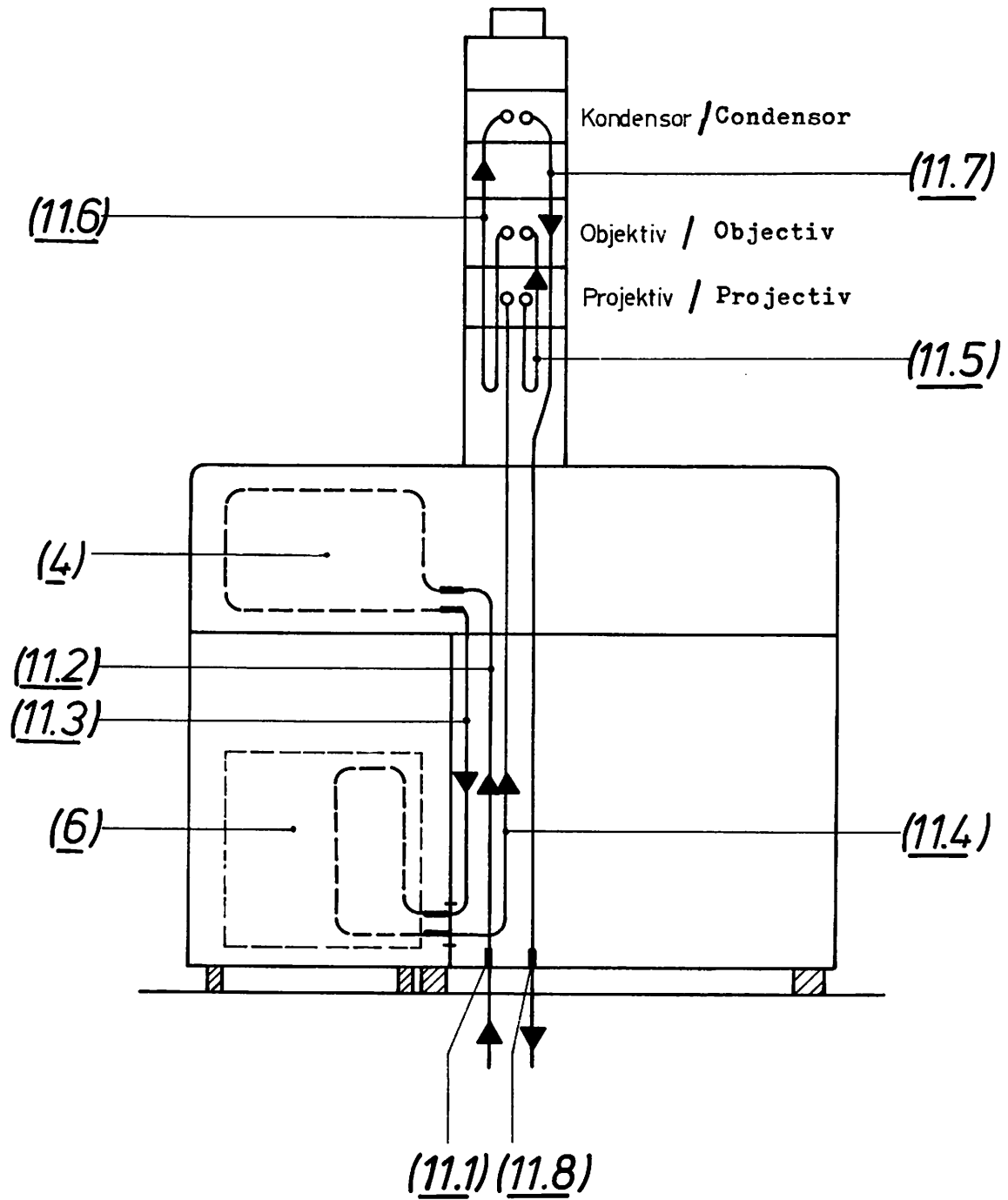
4.9 Power supply (6)

The power supply (6) is set up on separate, vibration-resistant supports without mechanical contact with the instrument base (2). The power input is at the back. The lower part contains a common transformer for lens current supply and lens current pre-control, the pump supply, and supply transformers and power supplies for the control electronics.

- (6.1) Power cable (without plug) for permanent connection to wall socket (not shown).
- (6.2) Power switch: I = normal position, 0 = instrument without current.
- (6.3) Operating hour counter
- (6.4) CEE socket: power plug (220V AC) for water supply magnetic valve (accessory) or for control line of closed-loop cooling system (accessory).
- (6.5) CEE socket: power plug (220V AC) for rotary pump (7).
- (6.6) and (6.7): CEE sockets: power plug (220V AC/2A) for accessories.

4.10 Fuses

	Value	Component
(6.8)	Fuse 1: 0.12A SB	Pump control
(6.9)	Fuse 2: 4A SB	Turbopump supply
(6.10)	Fuse 3: 0.63A SB	Pump control
(6.11)	Fuse 4: 1.6A SB	Lens supply, photography system
(6.12)	Fuse 5: 1A SB	High-voltage unit
(6.13)	Fuse 6: 0.63A SB	High-voltage unit
(6.14)	Fuse 7: 1.6A SB	Control of magnetic valve for water supply
(6.15)	Fuse 8: 4A SB	CEE sockets



4.11 Closed-loop cooling system

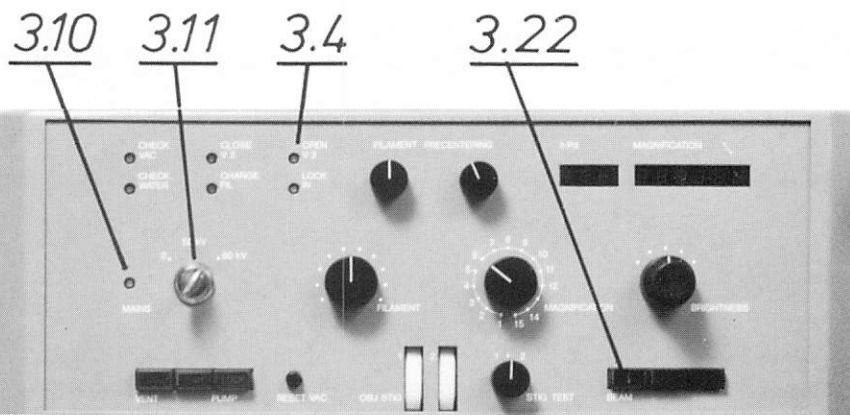
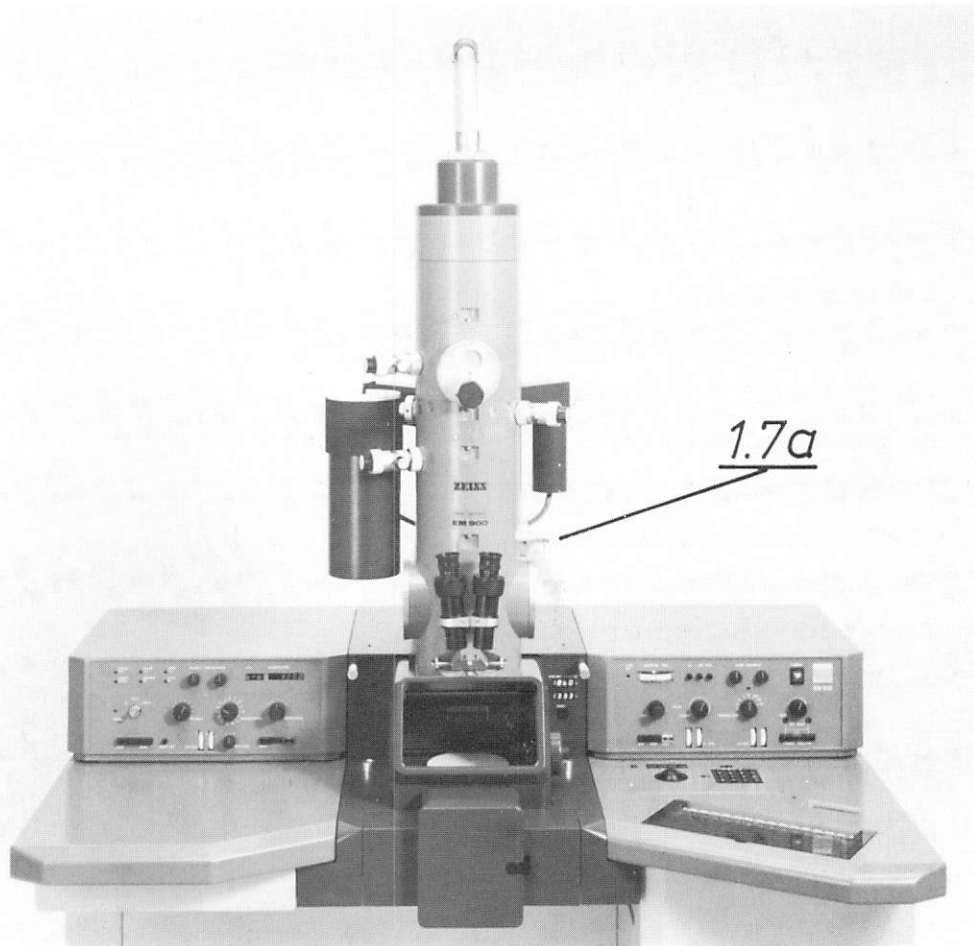
The following components are water-cooled because of the compact design of the electron optics or the electron-optical column respectively: lens current supply (power supply (6)), lens current control (back wall of right panel (4)) and all lens coils in the column.

- (11.1) Water inlet, nozzle for 8mm tube
- (11.2) 6mm tube: inlet to back plate of right panel
- (11.3) 6mm tube: right panel to power supply
- (11.4) 6mm tube: power supply to projector lens group
- (11.5) 6mm tube: projector lens group to objective lens
- (11.6) 6mm tube: objective lens-condenser group
(fall pipe meter)
- (11.7) 6mm tube: condenser group to water outlet
- (11.8) Water outlet: nozzle for 8mm tube

The fall-pipe meter in the permanently energized C1 coil monitors the cooling-water circulation. In case of water supply failure the C1 coil is heated up until the fall-pipe meter responds and turns off all lens coils (the same applies to a failure of the C1 lens current).

5.0 Operation of EM 900 Electron Microscope

Chapter		Page
1	Instrument switch-on	5.1
2	Electron-beam switch-on/off	5.2
3	Base adjustment of instrument after electron-beam switch-on, illumination system, imaging system, aperture and stigmator settings	5.3
4	Microscope adjustments magnification selection, image brightness, electronic stage positioning, viewing microscope	5.8
5	Microscopy, specimen exchange, specimen screening, High-Resolution imaging (HR), darkfield imaging, diffraction, Minimum Dose Focusing, Highest Magnification (HM), High-Contrast imaging (HC)	5.13
6	Operation of sheet film camera	5.28
7	Operation of TFP camera	5.33
8	Description and operation of vacuum system	5.35
9	Instrument switch-off	5.38
10	Displays for establishment of normal operating conditions	5.39



Chapter 1: Instrument switch-on

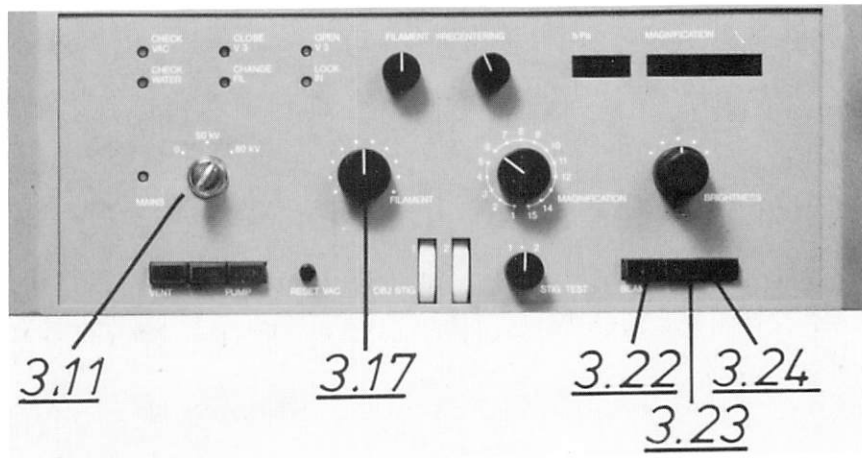
Starting position: Key switch (3.11) set to 0

Power signal lamp (3.10) lights.

Turning key switch (3.11) from 0 to 50/80kV starts the pump control program.

High-vacuum display from 5×10^{-3} to 1×10^{-7} mbar in decimal increments.

The lamp OPEN V3 (3.4) lights when the conditions for high-voltage go-ahead are obtained and the separating valve V3 (1.7a) can be opened. When V3 (1.7a) is open, lamp (3.22) lights, displaying high-voltage go-ahead, and the high voltage can be switched on (instrument ready for operation).



Chapter 2: Electron-beam switch-on/off

NB: The electron beam should be switched on only if the high vacuum is better than 2×10^{-5} mbar.

2.1 Set mode switch (3.11) to 50kV or 80kV.

2.2 "⚡" ON: depress green "⚡" key (3.22), lamp in red "⚡" key (3.24) lights; "⚡" is ON.

"⚡" OFF: depress red "⚡" key (3.24), lamp in green "⚡" key (3.22) lights; "⚡" is OFF.

2.3 Filament switch-on

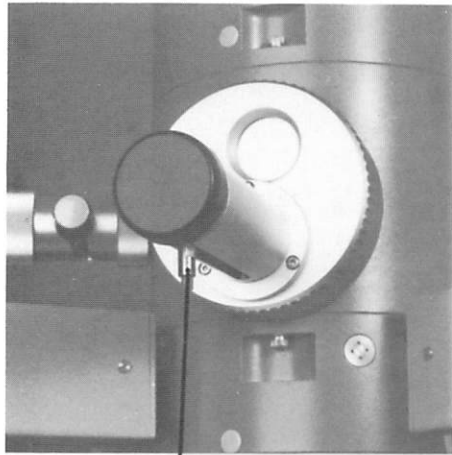
NB: High-voltage switch-on may impair the display of the operating vacuum. Before filament switch-on wait until the initial vacuum is re-established!

Check filament heating potentiometer (3.17) before switch-on (from left stop to middle of the range).

Caution: The filament is overheated if the potentiometer is near the right stop!

Filament switch-on: depress key (3.23), lamp in the key lights, filament is ON.

Filament switch-off: release key (3.23).



1.4

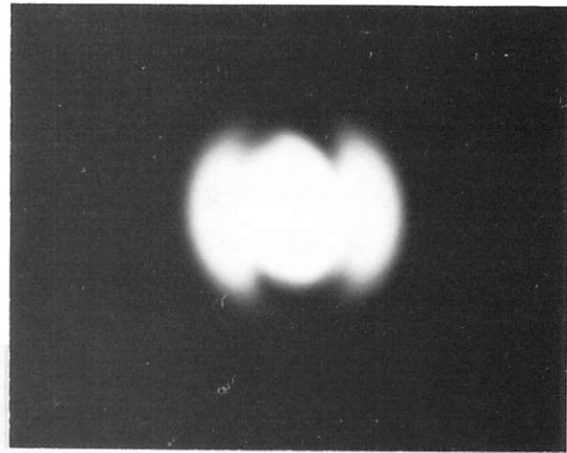
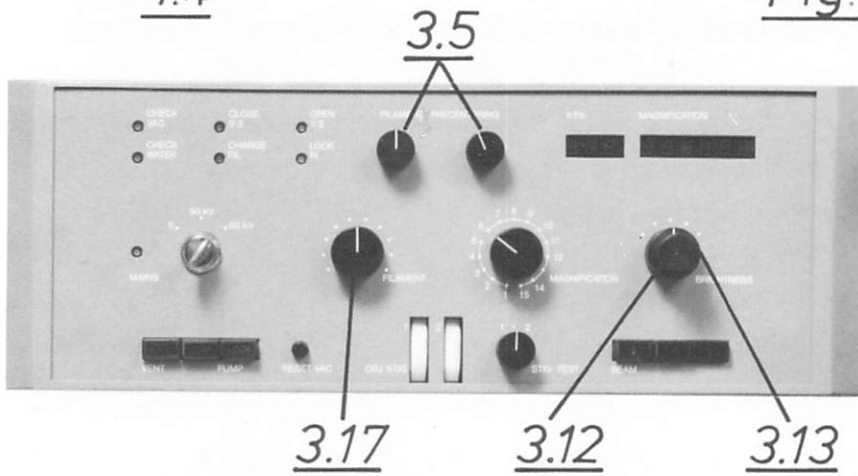


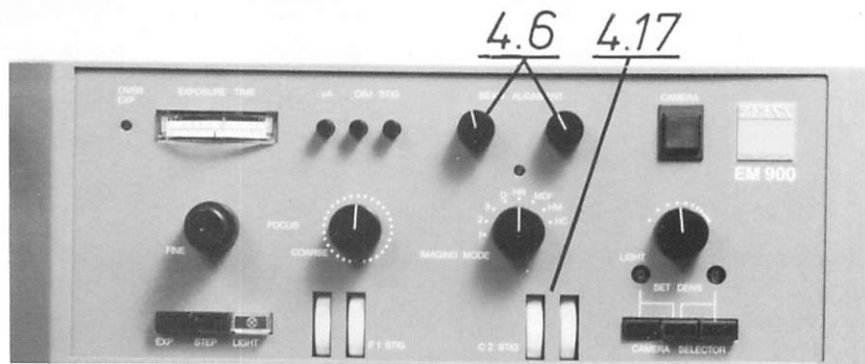
Fig. 1



3.17

3.12

3.13



4.6

4.17

Chapter 3: Base adjustments after electron-beam switch-on

3.1 Illumination system

Adjustment of filament heating and optimized brightness

Withdraw specimen (1.4) from beam path; condenser aperture inserted: magnification 3000x.

Narrow condenser as far as crossover with condenser potentiometer BRIGHTNESS (3.13); center luminous spot on fluorescent screen with potentiometer (4.6), and set beam current to step 5 with switch BRIGHTNESS (3.12); underheat filament with FILAMENT (3.17), the underheated filament lies in the middle of the luminous spot as shown in Fig. 1. Correct with FILAMENT PRECENTERING potentiometers (3.5) until the shadow image is symmetrized, and increase the filament heating with FILAMENT (3.17) until the luminous spot is homogeneous.

NB: For each beam current step heat filament only until homogeneous crossover is obtained; overheating shortens the life of the filament!

3.2 Condenser stigmator setting

Swing up focusing fluorescent screen.

Condenser aperture (400 μ m) inserted.

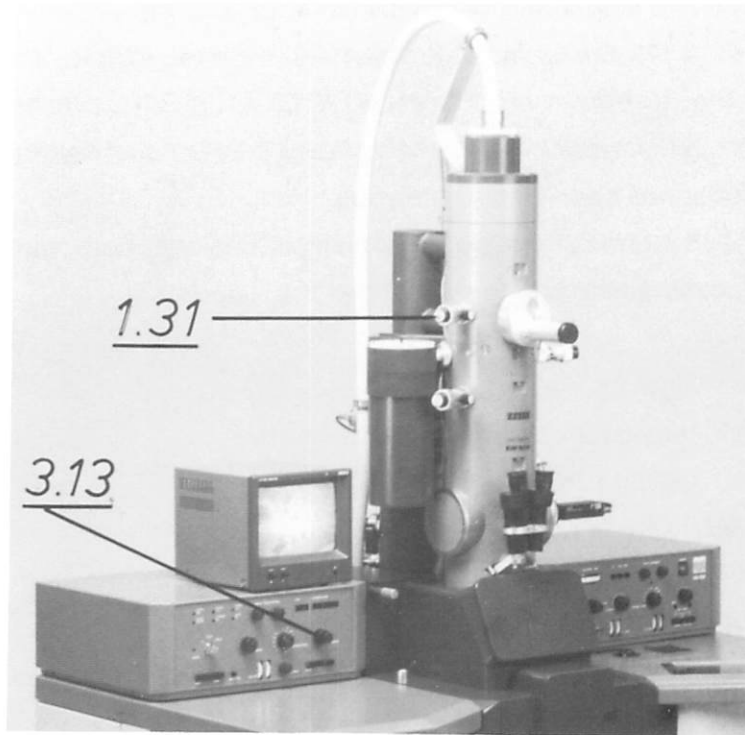
Through-focus the condenser.

The luminous spot is in focus (crossover).

Circular or slightly elliptical.

There is astigmatism if the axial orientation of the elliptical luminous spot is turned through 90° during through-focusing.

Adjust stigmator potentiometer (4.17) alternatively until the orientation of the ellipse remains the same.

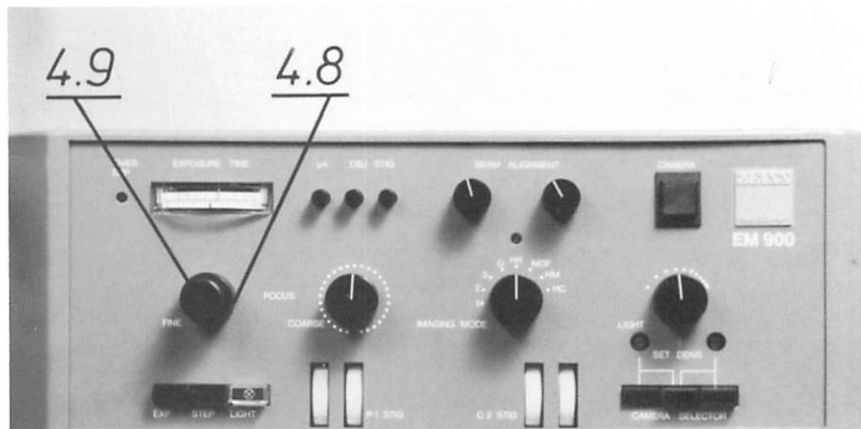
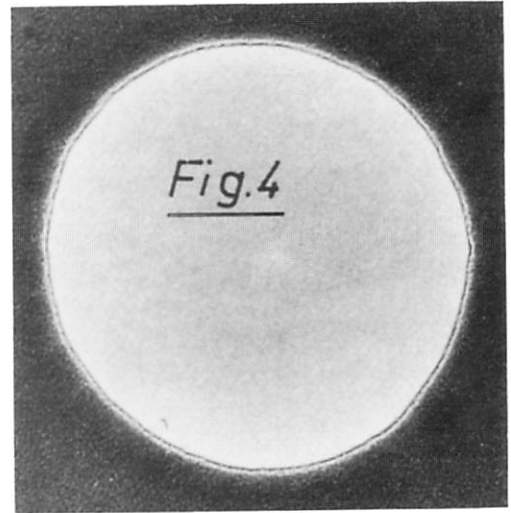
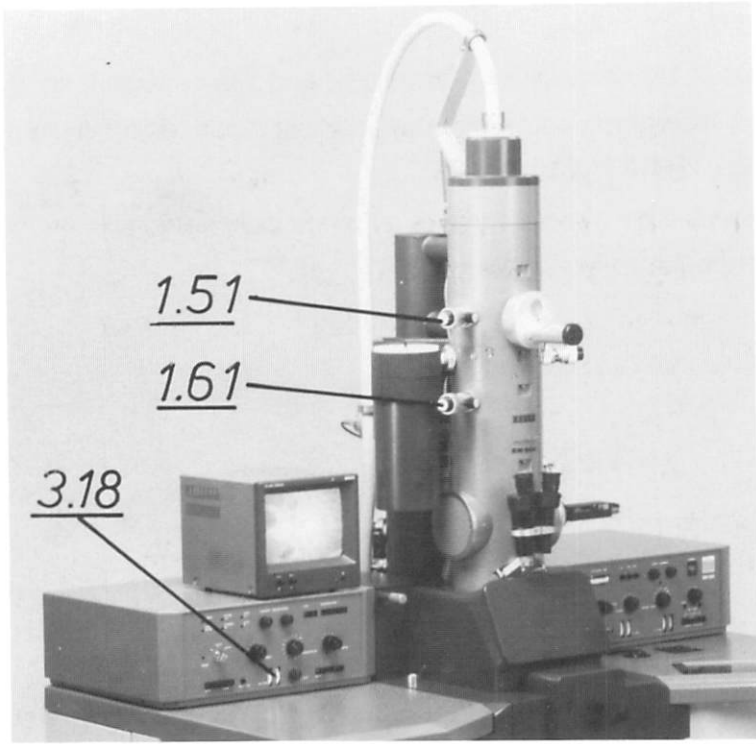


3.3 Centering the condenser aperture

Focus the luminous spot (crossover); if it deviates, shift beam to center of fluorescent screen with BEAM ALIGNMENT.

Turn condenser potentiometer (3.13) clockwise (defocusing), and if the aperture image expands eccentrically with the fluorescent screen marking, adjust it concentrically to the marking with condenser aperture drive (1.31).

The aperture is correctly centered if the aperture image expands concentric with the fluorescent screen marking during through-focusing.



3.4 Objective lens aperture (1.51) adjustment and compensation of objective lens astigmatism

3.4.1 Objective lens aperture (1.51)

Mode switch (4.10) to HR, perforated foil in the beam path; insert and center maximum 400 μm selector aperture (1.61); mode switch to D; focus the diffraction point with P1 potentiometer (4.9); insert desired objective lens aperture (1.51) and center it with reference to the diffraction point; mode switch to HR; retract selector aperture.

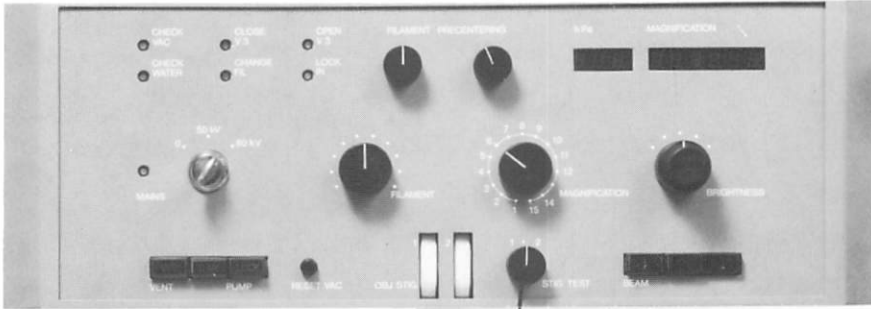
Special note: The following apertures are accommodated in the objective lens aperture holder:

Position 1: 7-hole thin-film aperture, 3x60 μm , 4x30 μm dia., recommended for conventional applications.

Position 2: single-hole thin-film aperture 90 μm dia. for high-resolution applications.

Position 3: single-hole thin-film aperture 180 μm dia. for imaging in HC mode.

3.4.2 Compensate objective lens astigmatism with perforated foil at 3000x to 400000x magnification, using 85000x or a higher magnification. Correct diffraction fringe in slight overfocus concentrically with the hole, as shown in Fig. 4. Correct with objective lens stigmator (3.18) or compensate objective lens astigmatism at 250000x magnification using the grain of the specimen. The specimen grain (e.g. support film) does not display a privileged direction during through-focusing.

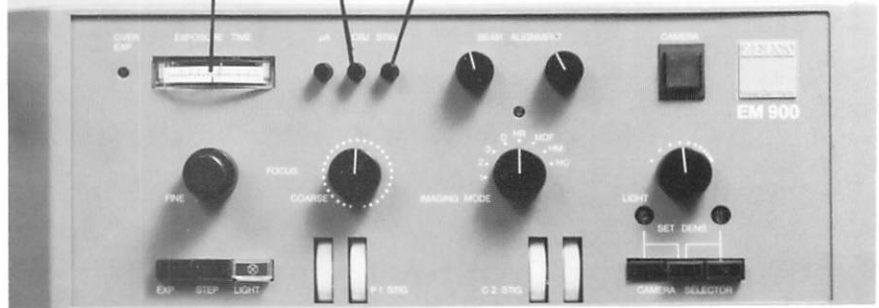


3.19

4.1

4.3

4.4



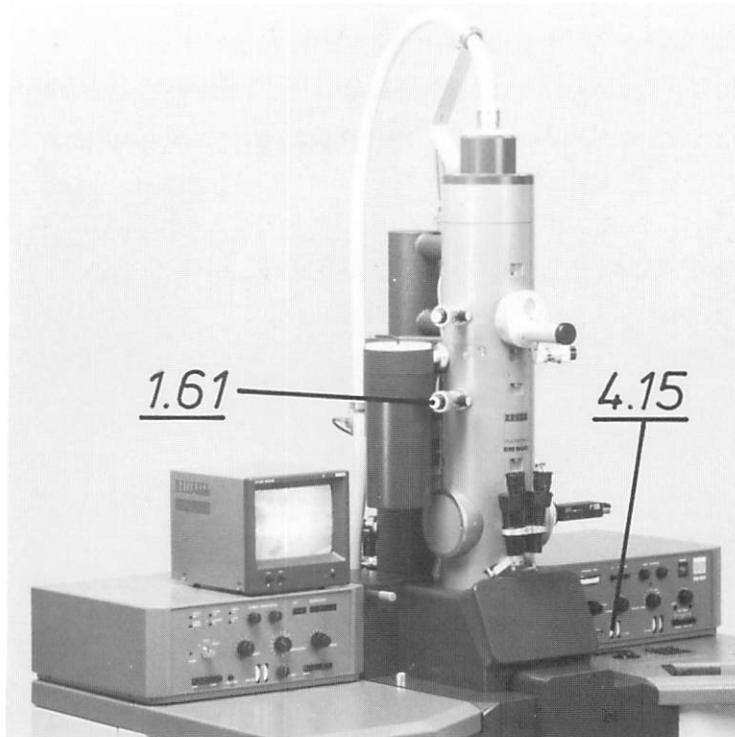
3.5 Brief check of objective lens stigmator setting without specimen

The test device serves to measure and test the stigmator setting. The stigmator values for exact astigmatism correction are determined once and written down. If the aperture is neither out of alignment nor contaminated, these values can be used for checking.

This is how these values are determined:

Exactly compensate astigmatism using a perforated foil or the grain of the specimen. Test switch (3.19) to 1. Depress key + (4.3) or - (4.4) to obtain a positive display on (4.1). Write down displayed value for test position 1. Determine and write down the value for position 2 in the same manner.

Control: If a value deviates clearly from the base values determined without objective lens aperture at 80kV or 50kV, the objective lens apertures may be poorly centered or contaminated.



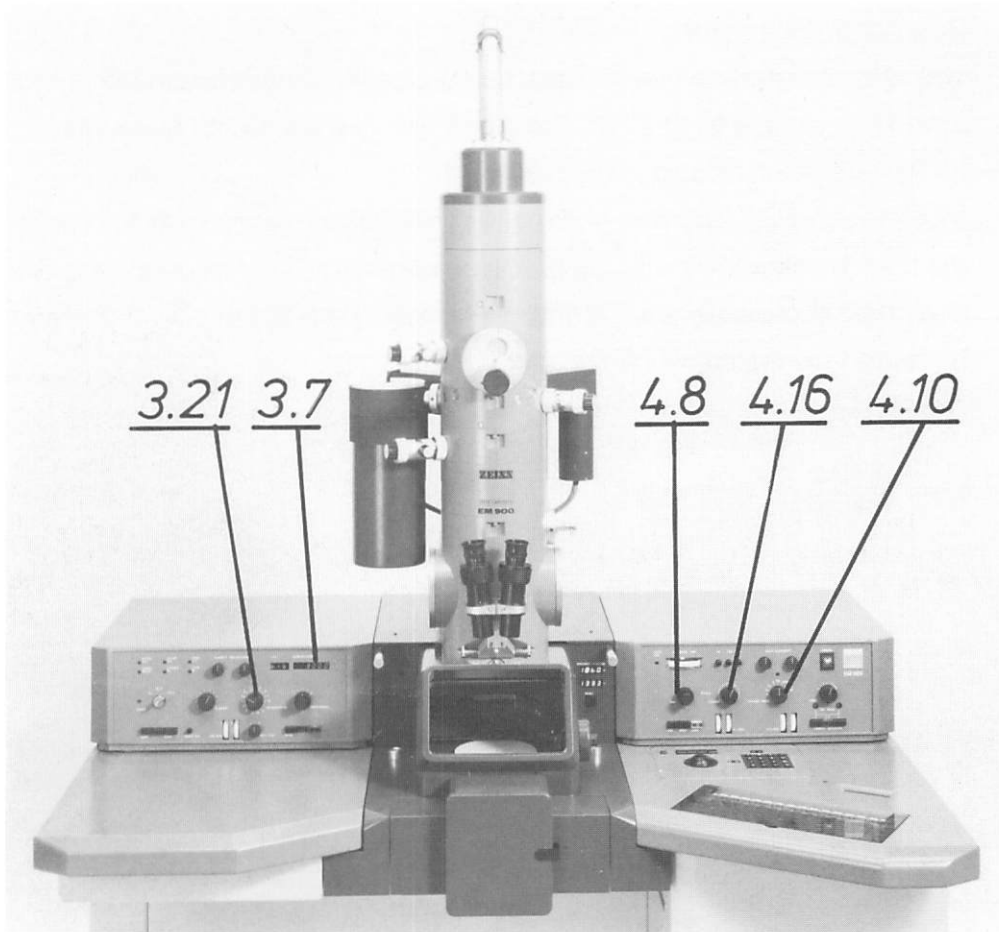
3.6 Projector lens stigmator (magnification range 150x - 1100x)

The P1 stigmator (4.15) is aligned at magnifications from 150x - 1100x (step 1 - 5). Pre-alignment: correct elliptical shape of the crossover on the focusing fluorescent screen in under- and overfocus with P1 stigmator (4.15). Final alignment: correct astigmatism and focus with stigmator (4.15) using the specimen grain. This alignment is dependent on the magnification and must be made separately for each magnification step.

3.7 Selector aperture (1.61)

The selector aperture can be used for contrast enhancement in the magnification range from 150x - 1100x (step 1 - 5). For diffraction take a selector aperture which does not cut off the specimen feature to be examined.

Insert the selector aperture (1.61) and symmetrize it to the large fluorescent screen in the X and Y directions with the precision controls of the aperture drive. The apertures should be completely retracted from the beam path at magnifications above 3000x, because they would cut off the image format.



Chapter 4: Microscope adjustments

- 4.1 How to use the 15-step magnification selector:
 Magnification change (standard cartridge)
 Mode switch (4.10) in position HR
 Switch (3.21) to select the magnification steps
 Digital magnification display (3.7).

Positions of imaging apertures

Magn.step	Objective lens aperture	Selector aperture
1 - 5	always retracted	Used as objective lens aperture
6 - 15	inserted	Inserted or retracted depending on the magnification

Magnification table

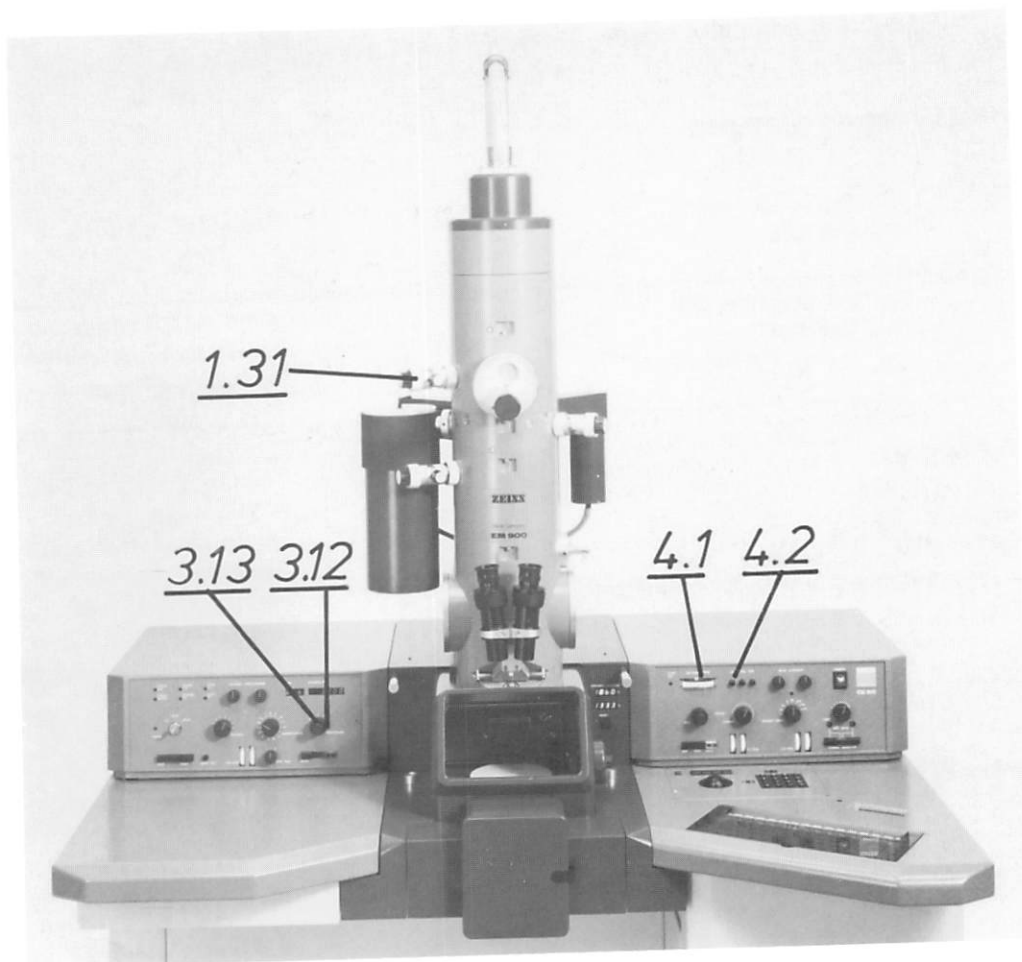
Magn.step	1	2	3	4	5	
Magnificat.	150x	250x	400x	700x	1100x	Focus maintained at all magnification steps 5 to 1 starting from focus step 5 with constant condenser setting
Focusing	continuously with P1 potentiometer (4.9)					

Magn.step	6	7	8	9	10	
Magnificat.	3000x	4000x	7000x	12000x	20000x	Focus (4.8)/(4.9) maintained at all magnification steps 15 to 6, from the high to the low magnifications.
Focusing step (nm)	960	480	480	240	120	

Magn.step	11	12	13
Magnificat.	30000x	50000x	85000x
Focusing step (nm)	120	60	30

Magn.step	14	15
Magnificat.	140000x	250000x
Focusing step (nm)	15	15

The focusing step is automatically matched to the magnification



4.2 Adjustment of image brightness

There are two methods to vary the image brightness.

4.2.1 Vary the image brightness by changing the beam current to assure constant irradiation conditions (specimen illumination, illuminating aperture).

NB: The higher the beam current, the greater the danger of damage to the specimen!

Beam current change: 5-step switch (3.12)

Beam current measurement: depress key (4.2); the beam current is displayed on (4.1)

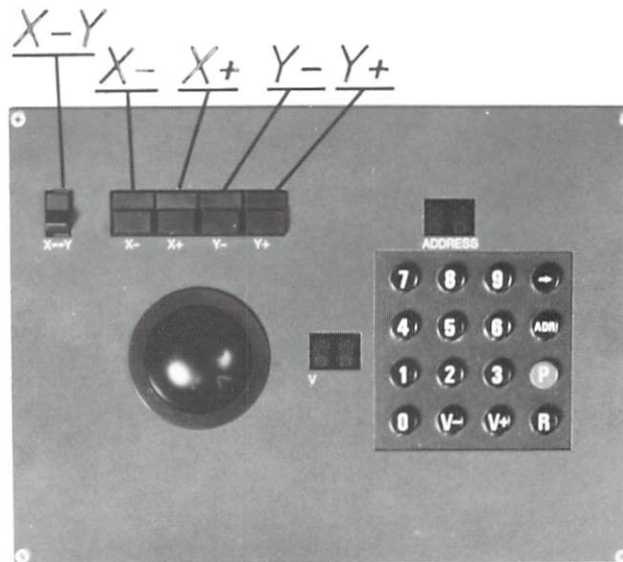
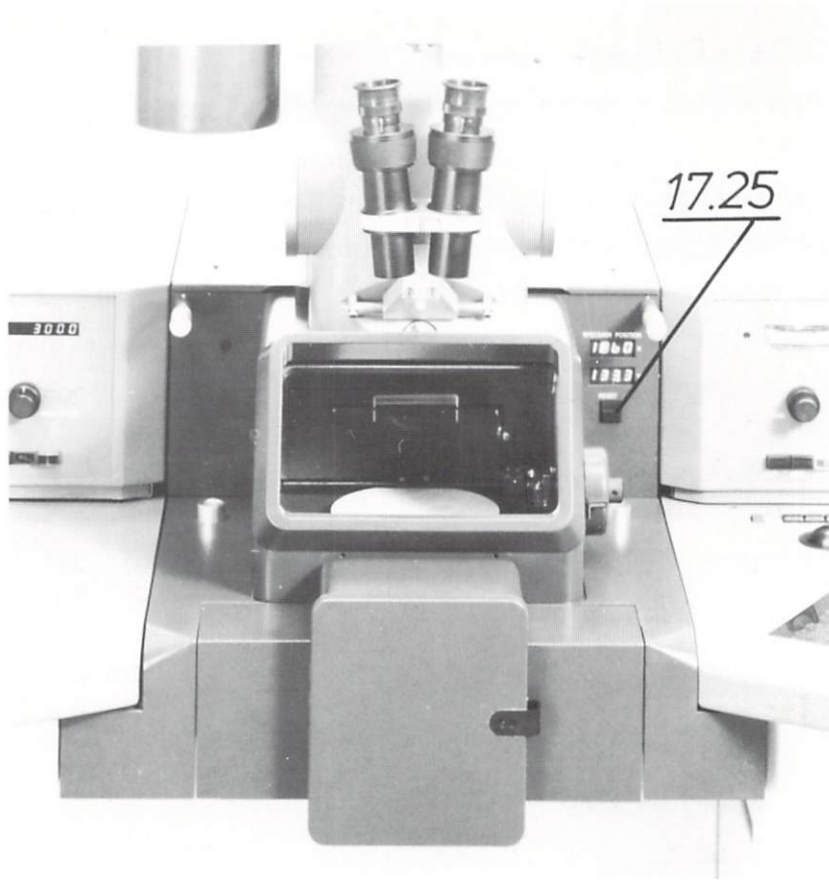
Beam current step		1	2	3	4	5
Beam current approx.	50kV	1	3	10	30	100
(μ A)	80kV	1	3	10	30	50

4.2.2 Brightness variation with fix-focus

Brightness adjustment with knob (3.13) or by changing the condenser aperture (1.31).

Condenser aperture	1	2	3
Aperture diameter (μ m)	400	200	100
Illuminating aperture (rad) with focused condenser	2.4×10^{-3}	1.2×10^{-3}	6×10^{-4}

5.10



4.3 Electronic stage positioning

4.3.1 Electronic unit (front panel):

LED displays for X, Y specimen position (SPECIMEN POSITION)

Displays in μm

Range X: 0000 - 2000

Y: 0000 - 2000

Middle position: 1000 / 1000

NB: If the specimen stage is moved beyond the 0000 position, the display is reversed so that e.g. 9999 corresponds to -0001

Depressing the RESET key (17.25):

- sets all memories to middle position, i.e. to 1000 / 1000
- sets the transmission of the speed of the trackball motion to that of the stage to the medium step, i.e. 09
- calls memory 00

4.3.2 Control panel for stage positioning

Four pushbuttons for quick coarse positioning of the stage in all four directions:

X -: X position towards lower display

X+: X position towards higher display

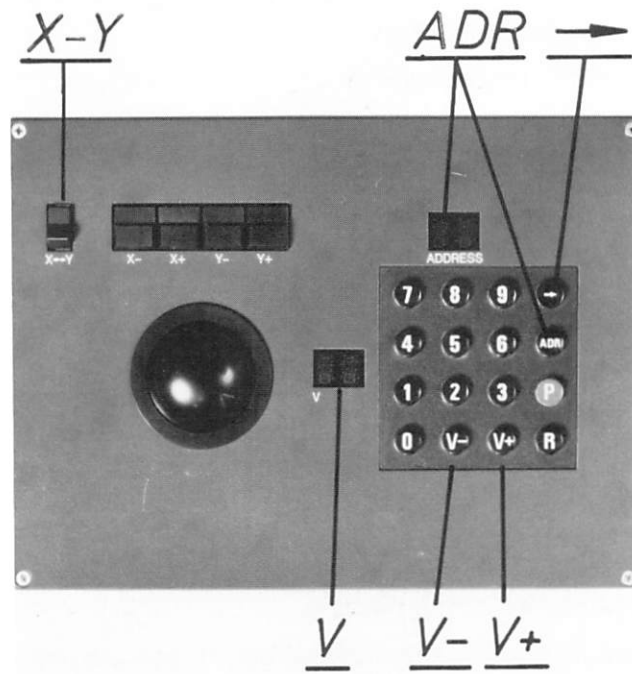
Y -: Y position towards lower display

Y+: Y position towards higher display

The speeds of coarse positioning and trackball motion are adjusted to the magnification:

M = 150x approx. $570\mu\text{m/s}$ approx. 3.5s for 2 mm

M = 250000x approx. $0.44\mu\text{m/s}$ approx. 230s for 0.1mm



When the stage positioning is operated, the internal counter continues at the limit stop. Motor and digital display stop. If the motion direction is reversed, the internal counter runs to the limit position where the motion direction is reversed.
X-Y change of motion direction for normal observation and observation on the TV monitor.

4.3.3 Trackball for precision stage positioning

The transmission of the speed of the trackball motion to that of the stage can be varied by a factor of 2 in 16 steps. The speed is adjusted to the magnification.

4.3.4 LED display V for the steps 01 through 16

slowest step: 01

fastest step: 16

The steps are adjustable with the keys V+ and V- on the keyboard.

V+: 08, 09, 10,, 16, 01, 02,, 16, 01,

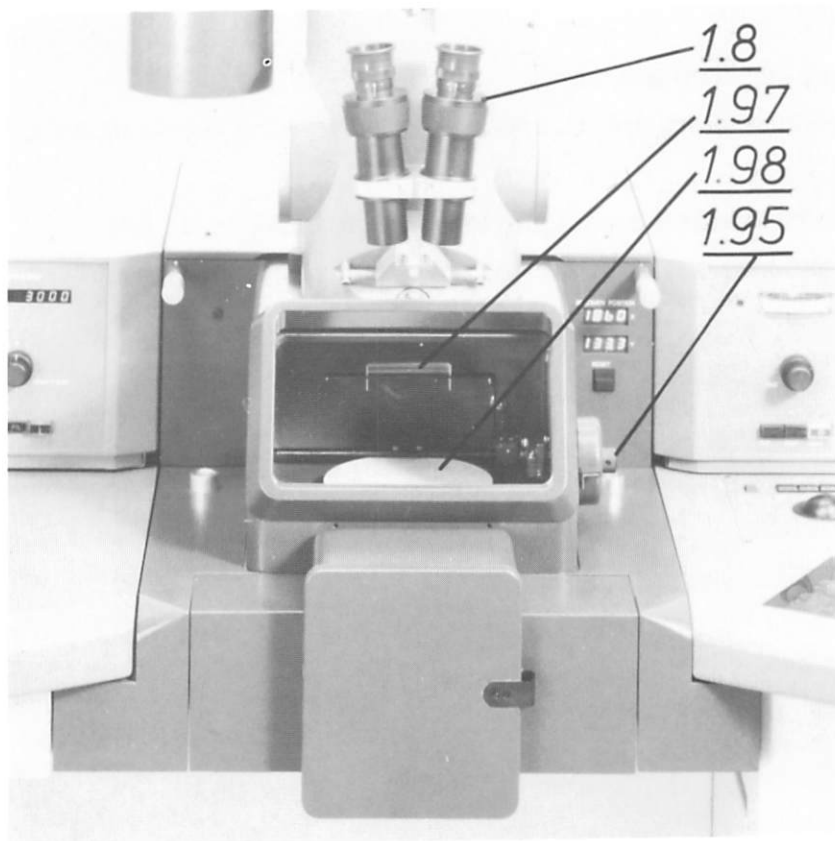
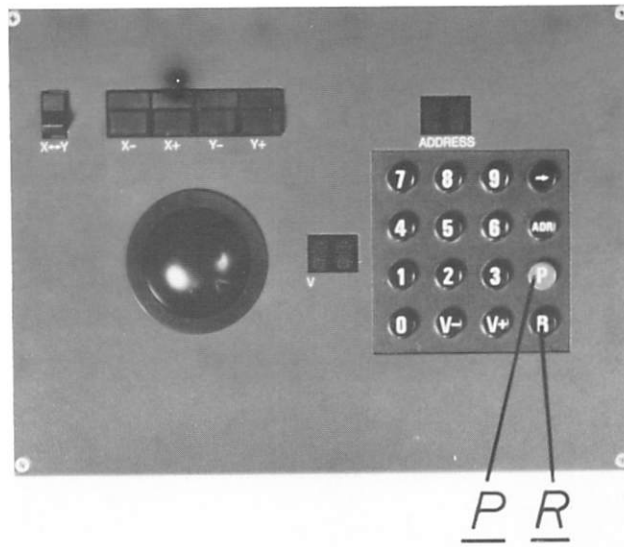
V -: 08, 07, 06,, 01, 16, 15,, 01, 16,

4.3.5 Memory selection and display

A memory address from 0 to 99 is keyed in from the keyboard and called with the key ADR.

Each addressed memory is displayed by the LED display ADR.

The memories can be addressed in ascending order with the key :, 03, 04, 05, 06,



4.3.6 Storing an X,Y position

An X,Y position set with the trackball or a pushbutton is read into an addressed memory with the key P on the keyboard.

4.3.7 Retrieving and relocating an X,Y position

A stored X,Y position read in an addressed memory is retrieved with the key R on the keyboard.

If a memory without read-in X,Y position is used, the stage moves to the middle position 1000 / 1000 when the key R is depressed.

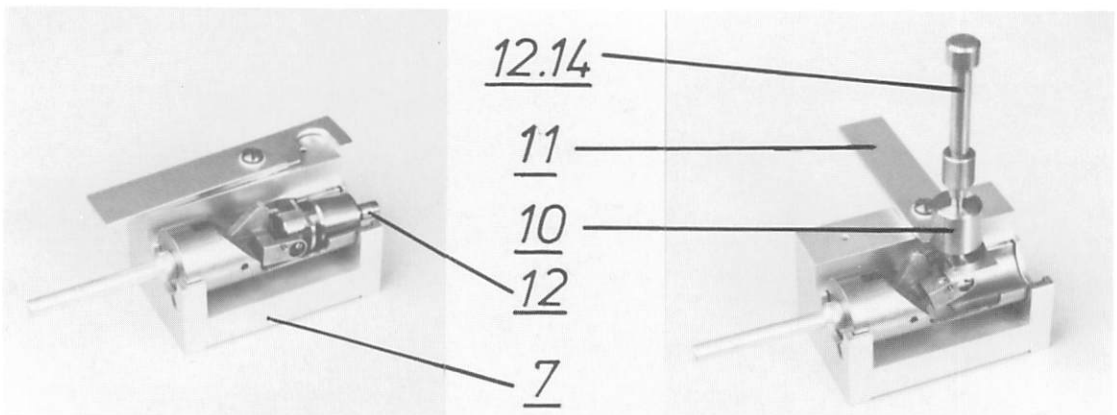
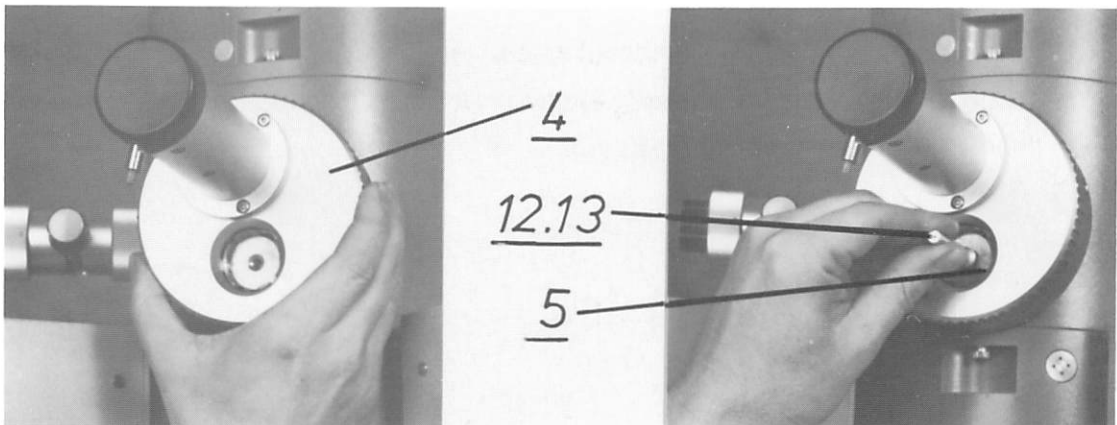
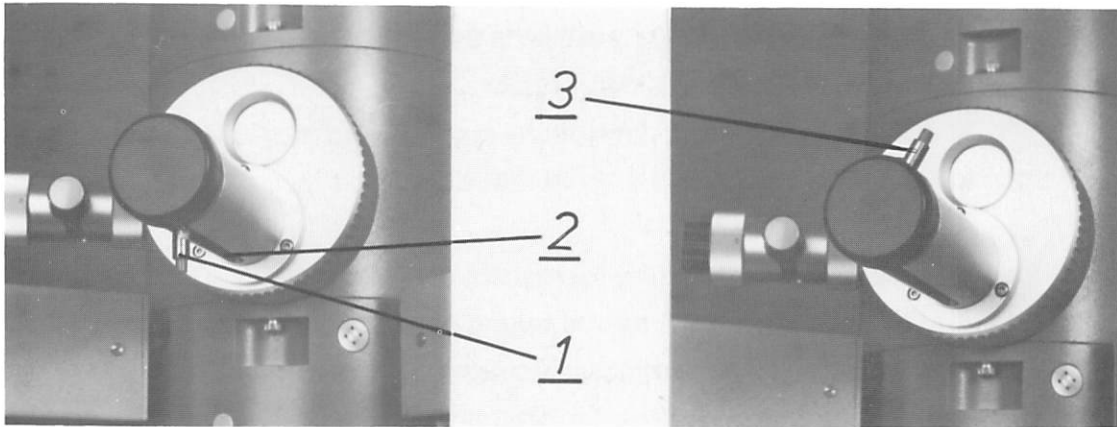
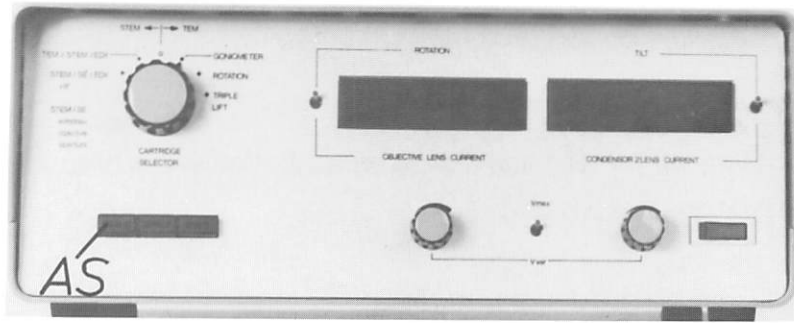
NB: At a speed of approx. 0.12mm/s the stage always moves first to the stored X and then to the stored Y position, i.e. 2mm within approx. 17s.

4.4 Viewing microscope for focusing fluorescent screen

The viewing microscope (1.8) can be swung down for observation of the focusing fluorescent screen (1.97), and moved across the screen. The PD is adjusted by moving the microscope tubes in and out. To focus on a mark in the center of the screen turn the eyepieces in or out.

4.4.1 Observation of the large fluorescent screen (1.98)

Swing the viewing microscope (1.8) up until it snaps in, and swing the focusing fluorescent screen out with knob (1.95).



Chapter 5: Microscopy

5.1 Specimen exchange (lock-in/out)

Lock-out

NB: If motor or manual drives are mounted for specimen manipulation cartridges, set first to lock-out position: AS or 000.

Pull rod (1) in link guide (2) out all the way, turn it in snap ring groove (3) as far as it will go, and pull it out until it snaps in.

The airlock is ventilated if the large knurled ring (4) is turned fully anticlockwise.

Screw key (12.13) loosely into slide (5), pull out slide and place it on specimen changer (7).

Shut airlock tube.

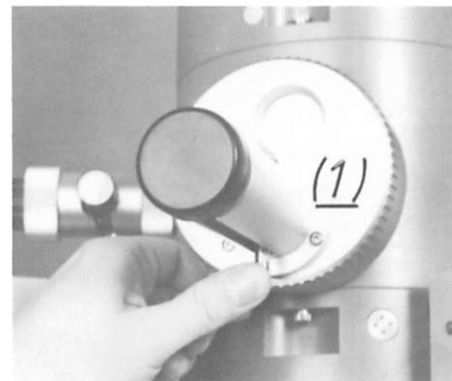
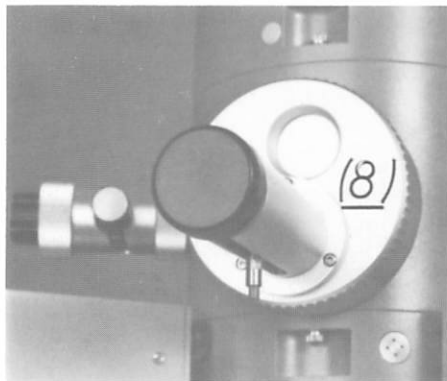
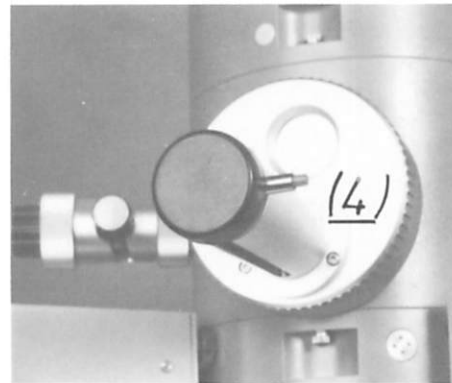
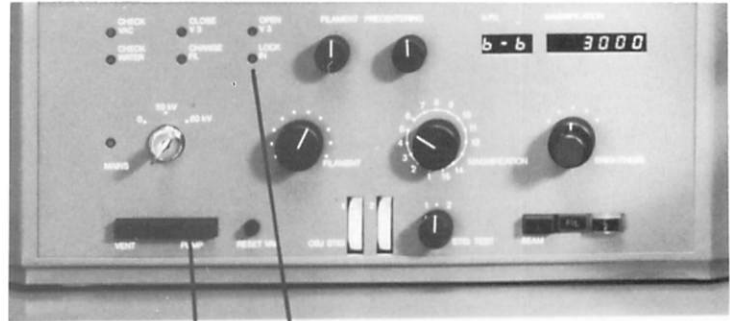
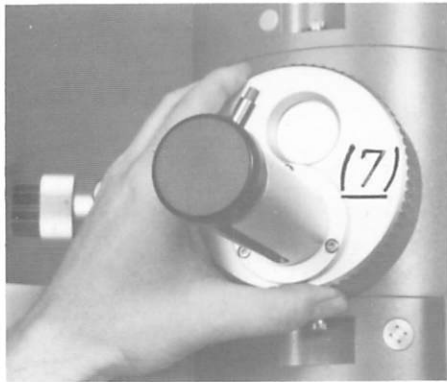
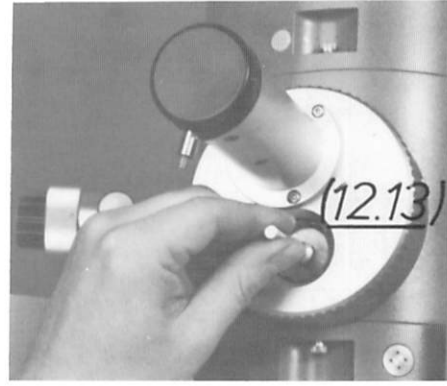
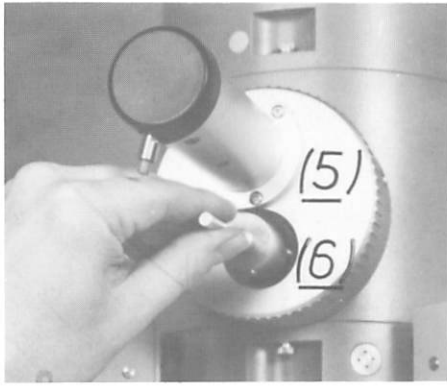
5.2 Specimen exchange

Place cartridge (10) upright and secure it with holder (11). Unscrew cap (12) with pinion wrench (12.14).

Swing aside holder (11), lower cartridge with wrench (12.14) (do not let it drop) and pull off wrench (12.14).

Do not leave airlock tube open too long, and never touch cartridge and slide!

Water (humidity of the air and finger sweat) in the high vacuum will extend the pump-down times.



5.3 Lock-in

Open airlock tube. Push slide (5) into airlock tube (mind locking pin (6)) and unscrew wrench (12.13). Close airlock all the way by turning large knurled ring (7) clockwise.

Important: Depress key PUMP (3.16) to evacuate the airlock. The pre-vacuum pump evacuates the airlock.

Depress airlock knob (8), unlock airlock rod (9), push it in all the way, turn rod clockwise in snap ring groove only as far as horizontal position (4): the airlock is evacuated.

Wait until the green lamp in key LOCK IN (3.3) goes on: go-ahead for airlock.

NB: Approx. 5s are required for pre-evacuation. The longer the pump-down time the better the pre-vacuum. The pre-vacuum pump is switched back to the camera chamber after 30s (noticeable by the noise of the magnetic valves).

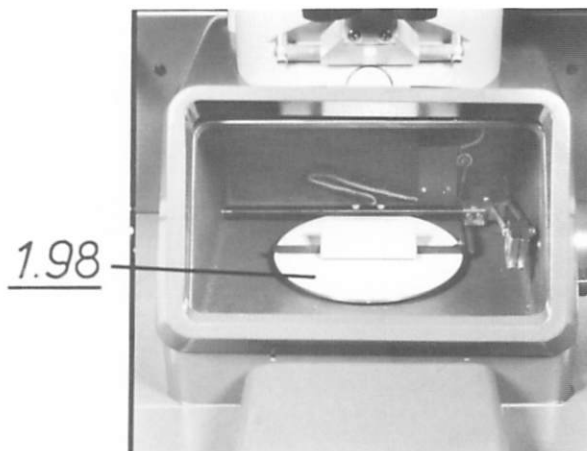
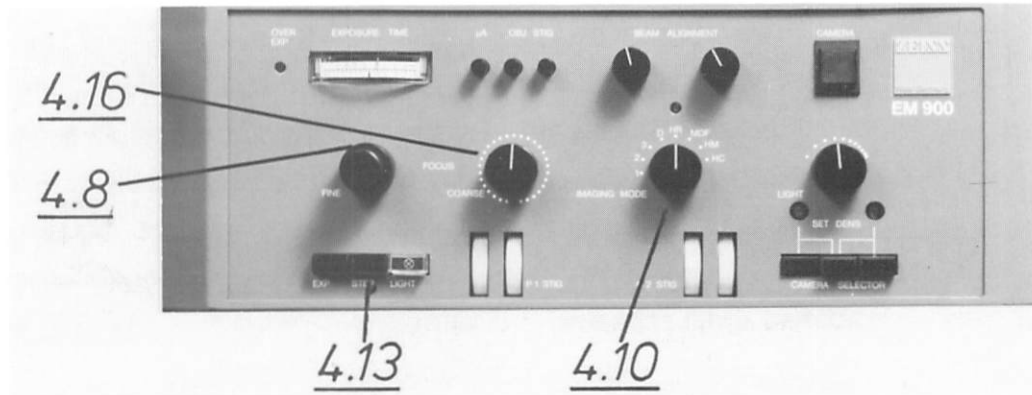
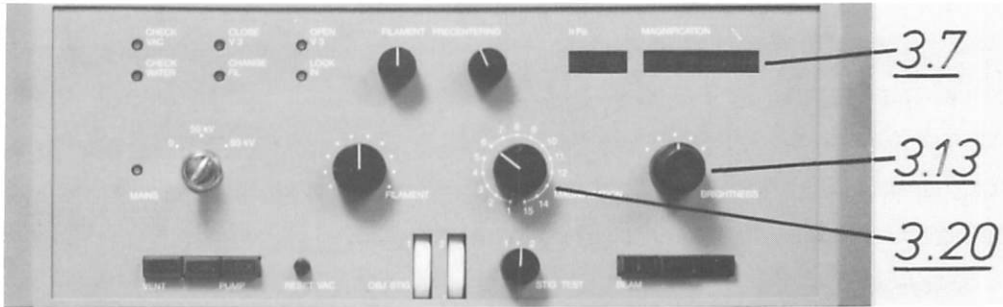
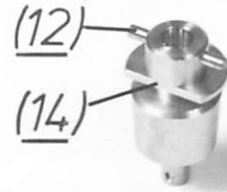
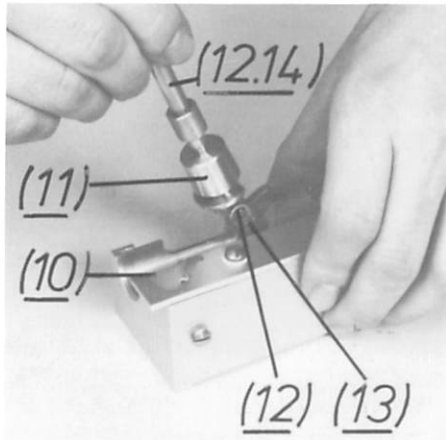
Turn rod fully clockwise and slide it in straight until it snaps in (waiting position).

Depress knob (8) and push in rod as far as intermediate stop. Depress knob (8) again and insert rod slowly as far as stop (1). The rod springs slightly back which disengages the cartridge.

5.4 Airlock operation

Airlock operation is possible only in normal mode (the conditions specified under 6.2.7 must be fulfilled). If the key LOCK (3.16) is activated both angle valves are shut for 30s and the lamp in LOCK IN (3.3) goes on. The lamp in LOCK IN (3.3) goes out during lock-in (airlock rod in 3 o'clock position) and on again if a pre-vacuum of better than 1×10^{-1} mbar is obtained (lock-in time approx. 5s). Both angle valves are successively opened again after 30s.

5.15



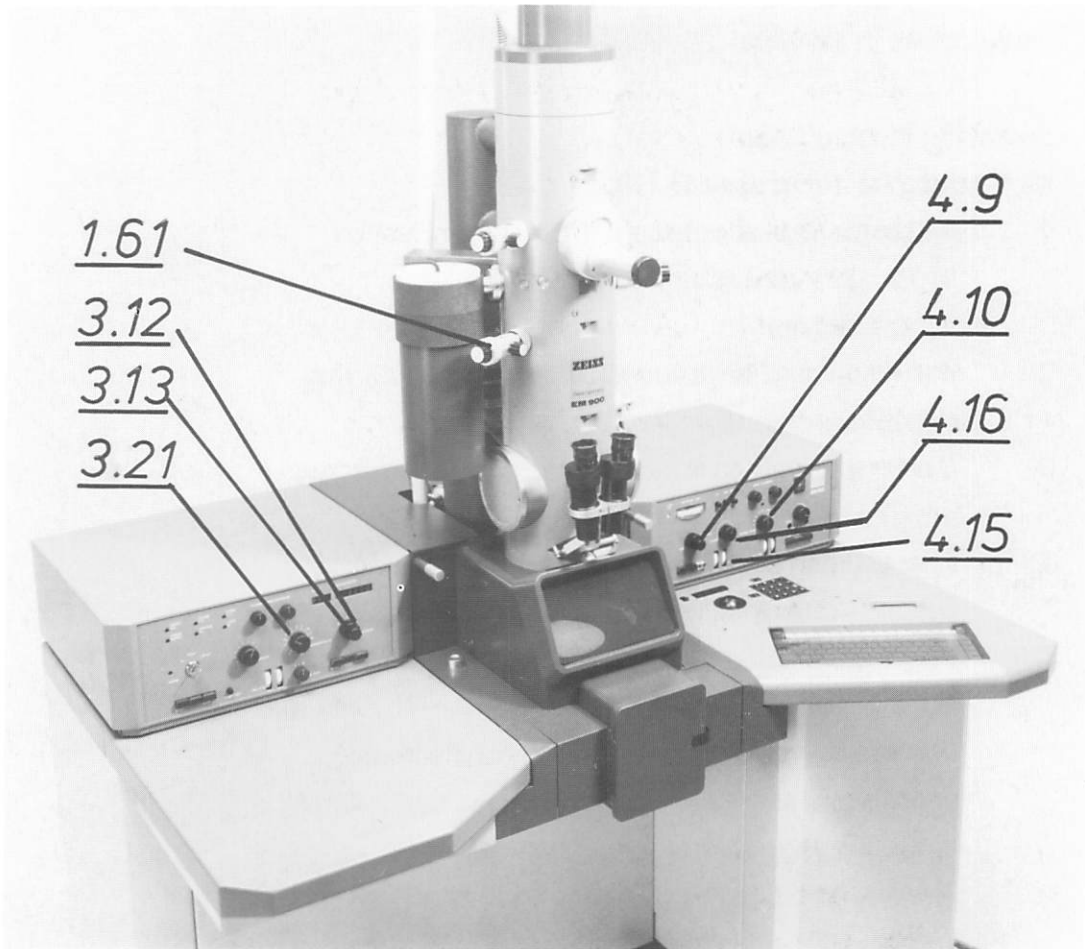
5.5 Cartridge change (between standard and special cartridges)

Place slide (20) with cartridge (11) on specimen changer as described under 4.11. Catch cartridge with wrench (12.14), swing it up and pull lateral shank screws (12) out of eyes of fork (13). Insert shank screws of new cartridge first into closed than into open eye of the fork; the milled side of the cartridge flange (14) must be face up if the cartridge lies in the slide.

5.6 Screening the specimen

Mode switch (4.10) in position HR.

1. Select magnification step 6 (3.20): magnification 3000x (3.7), part of a grid mesh on the large fluorescent screen.
2. Fully illuminate large fluorescent screen (1.98) with condenser potentiometer (3.13).
3. Center a specimen feature on the fluorescent screen with the specimen shift.
4. Focusing the specimen: at first with coarse focusing control (4.16), then with fine focusing control (4.8); the precision focusing step is changed at the ratio 4:1 with key (4.13).
Use magnification step 1 (150x) to locate large specimen areas. Settings as described under items 4, 5, 6 on page 5.17.
The further procedure depends on the type of specimen and the chosen imaging mode.



5.7 Imaging large specimen areas with high contrast and low specimen contamination: low magnifications (150x - 1100x)

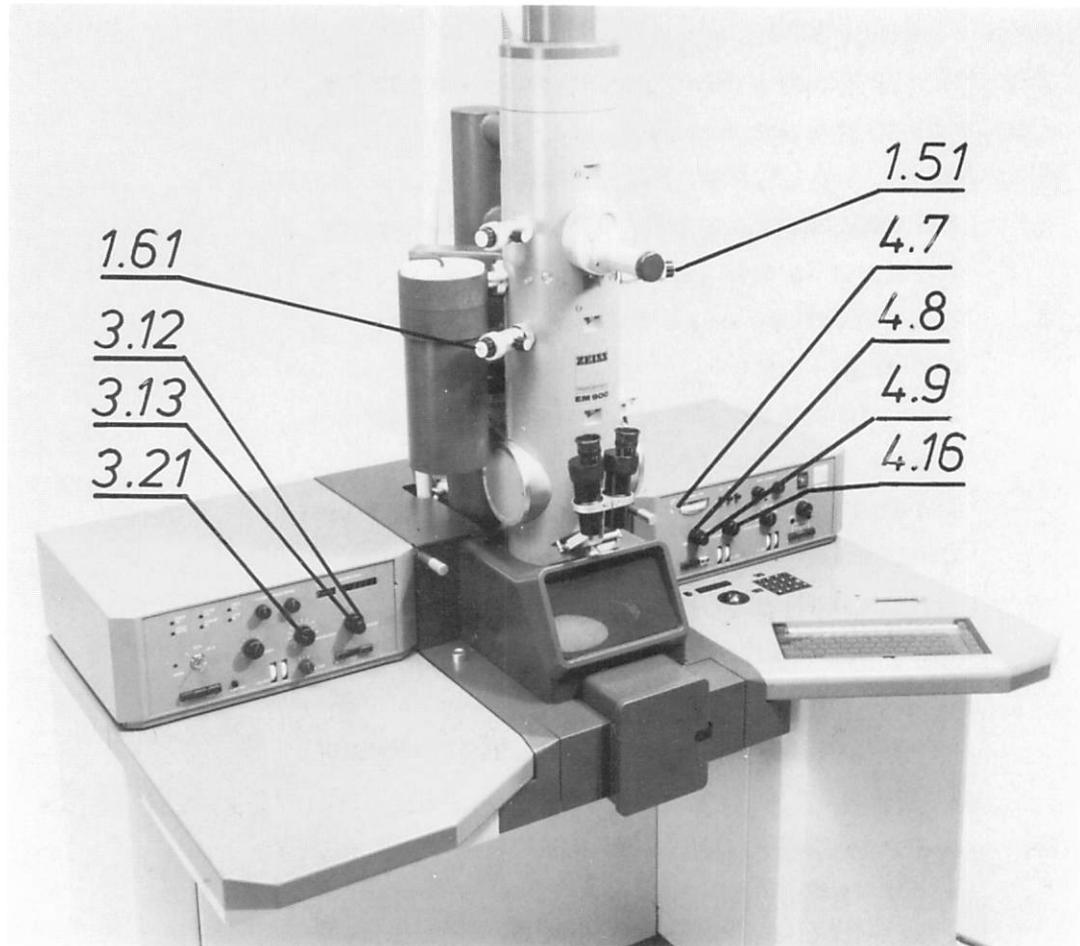
Requirements: 400 μ m dia. condenser aperture inserted and centered in magnification range II (as from 3000x). Condenser astigmatism compensated in the magnification range II (as from 3000x).

Objective lens focusing approximately in middle position.

Objective lens aperture retracted.

Magnification step 1-5, M = 150x - 1100x (3.21)

- 1. Set magnification to 150x; fully illuminate the fluorescent screen with condenser (3.13).**
- 2. Move specimen area of interest to center of fluorescent screen.**
- 3. Insert desired selector aperture (1.61) (see table below), center and fully retract it.**
NB: Eliminate any cutoff of the field by the smallest selector aperture with the objective lens coarse focusing control (4.16).
- 4. Set switch (3.21) to step 5: M = 1100x.**
Set beam current (3.12) to step 4 or 5 or narrow luminous spot with condenser (3.13) if the image brightness is low.
- 5. Focus specimen with P1 potentiometer (4.9).**
- 6. Compensate astigmatism with P1 stigmator (must be exactly aligned for each magnification step (1-5)).**
Set mode switch (4.10) to D.
Condenser control fully anticlockwise.
Adjust caustic figure with P1 stigmator potentiometer (4.15) (Mercedes star).
Set mode switch back to HR.



7. Fully illuminate large fluorescent screen and insert previously centered selector aperture (1.61).

Aperture no.	1	2	3
Aperture dia. (μm)	400	200	50
Imaging aperture (rad)	1×10^{-3}	5×10^{-4}	1.25×10^{-4}

8. Focus specimen with P1 potentiometer (4.9).
9. Select magnifications below 1100x with switch (3.21): Focus obtained under 6. is maintained as long as the P1 focus (4.9) is not changed.
10. If the automatic exposure control overfocuses (4.7) when the magnification is reduced, reduce brightness with condenser (3.13) or beam current control (3.12) until lamp (4.7) goes out.
Exposure see Chapter 5.19.

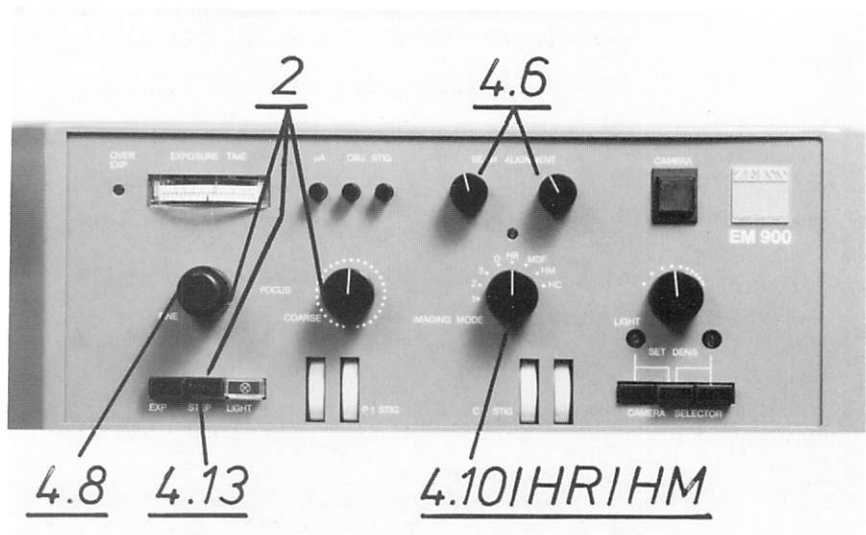
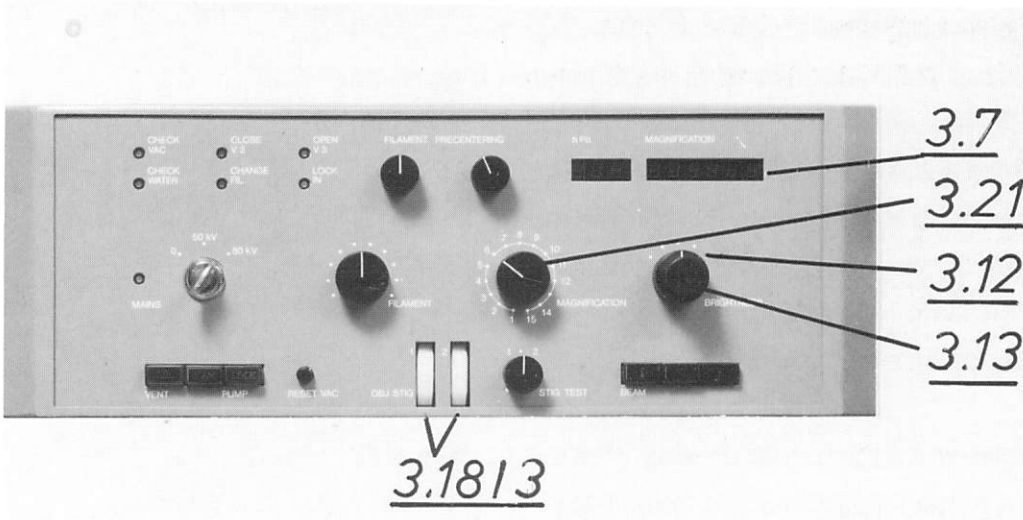
5.8 High-resolution imaging: Mode switch (4.10) in position HR
Medium and high magnifications (step 6-15)

A specimen feature is focused in the center of the fluorescent screen.

1. Select and center objective lens aperture (1.51).

Aperture no.	1	2	3
Aperture dia. (μm)	4x30/3x60	90	180
Imaging aperture (rad)	$6 \times 10^{-3} / 1.2 \times 10^{-2}$	1.7×10^{-2}	3.4×10^{-2}

2. Select high magnification step 15 or 14 (e.g. 250000x or 140000x) and focus specimen with (4.8)/(4.16).
Re-adjust brightness with condenser focusing control (3.13) and/or by increasing the beam current with (3.12).



3. Check objective lens stigmator setting:
either as described under 3.5/3.6 above,
or check and correct using the grain, if the specimen permits.
4. Select magnification for exposure:
(Focus (2.) and stigmator setting (3.) are maintained
at all magnification steps of ranges III and III!)
5. Adjust brightness for exposure only with condenser
(3.13).

Irradiation conditions with focused condenser:

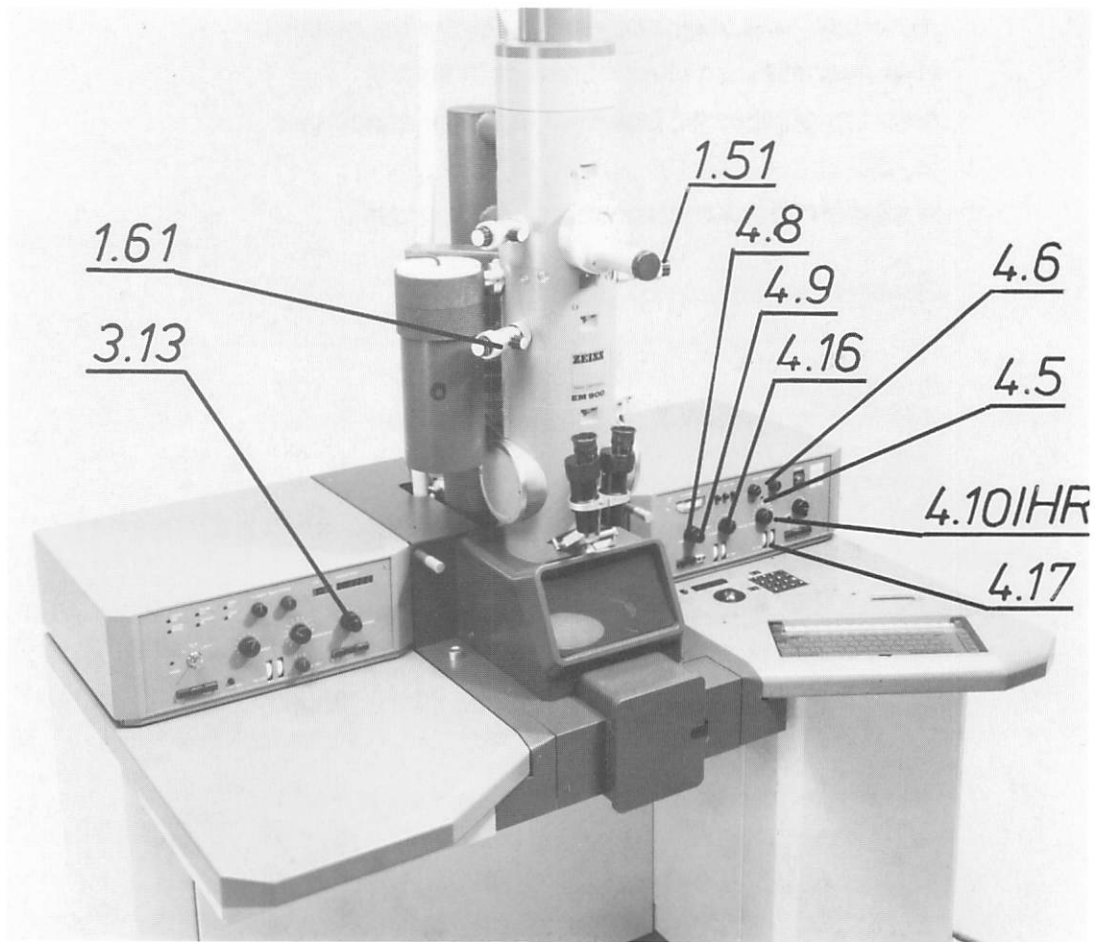
Condenser aperture no.	1	2	3
Aperture dia. (μm)	400	200	100
Illuminating aperture (rad)	2.4×10^{-3}	1.2×10^{-2}	6×10^{-4}

For exposure see Chapter 6.

5.9 Highest magnification

Mode switch to HM. Mode HM is operative only in step 11-15 magnification range.

1. Mode switch (4.10) first to HR position.
2. Select magnification range with switch (3.21): 30000x
to 250000x.
3. Center specimen feature on fluorescent screen and
focus (4.8)/(4.13).
4. Adjust condenser (3.13) to minimum spot; condenser
aperture $400\mu\text{m}$. Increase beam current (3.12) to assure
sufficient image brightness.
5. Switch to HM with mode switch (4.10): display
400000x on (3.7).
6. Optimize brightness with precision beam current
alignment (4.6).
7. Re-focus specimen, turn fine focusing control (4.8)
anticlockwise (depressing key (4.13) enhances the
focusing step).
8. Adjust objective lens stigmator (3.18) using
perforated foil or specimen grain.
9. Exposure: high resolution at highest magnification.



5.10 Strioscopic darkfield (accessory)

Required: annular condenser aperture, 40 or 30 μ m single-hole objective lens aperture.

1. Select a magnification of at least 30000x; condenser exactly in crossover; center luminous spot on fluorescent screen with beam alignment potentiometer (4.6); leave this adjustment unchanged.
2. Select magnification 3000x.
3. Insert annular condenser aperture and align it so that it is undistorted and concentric with the crossover; symmetrize crossover geometry with K2 stigmator (4.17)
4. Insert specimen and set mode switch (4.10) to D.
5. Focus annular aperture with P1 focusing control (4.9).
6. Insert 40 (30) μ m single-hole aperture (1.51) which cuts off the annular aperture completely.
7. Set mode switch (4.10) to HR, select a magnification of at least 30000x, because the illumination will be inhomogeneous otherwise!
8. Insert spectrometer slit and align.

5.11 Diffraction

Mode D for diffraction imaging of crystalline objects.

Selected area diffraction

1. Mode switch first in position HR
Magnification range II or III
Condenser (3.13) overfocused, fluorescent screen fully illuminated.
Lamp in (4.5) goes on if a mode other than HR is selected.
2. Focus specimen in center of fluorescent screen (4.16)/(4.8), and leave objective lens focus unchanged thereafter.
3. Take a selector aperture (1.61) which best matches the specimen feature to be examined.

Selector aperture no.	1	2	3
Selector aperture dia. (μ m)	400	200	50
Specimen area (μ m)	12	6	1.5

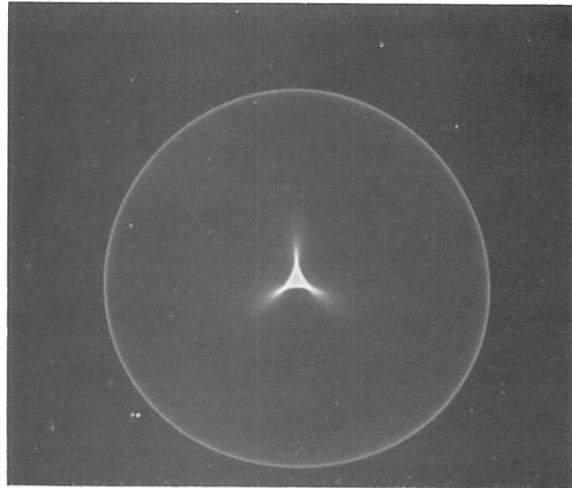
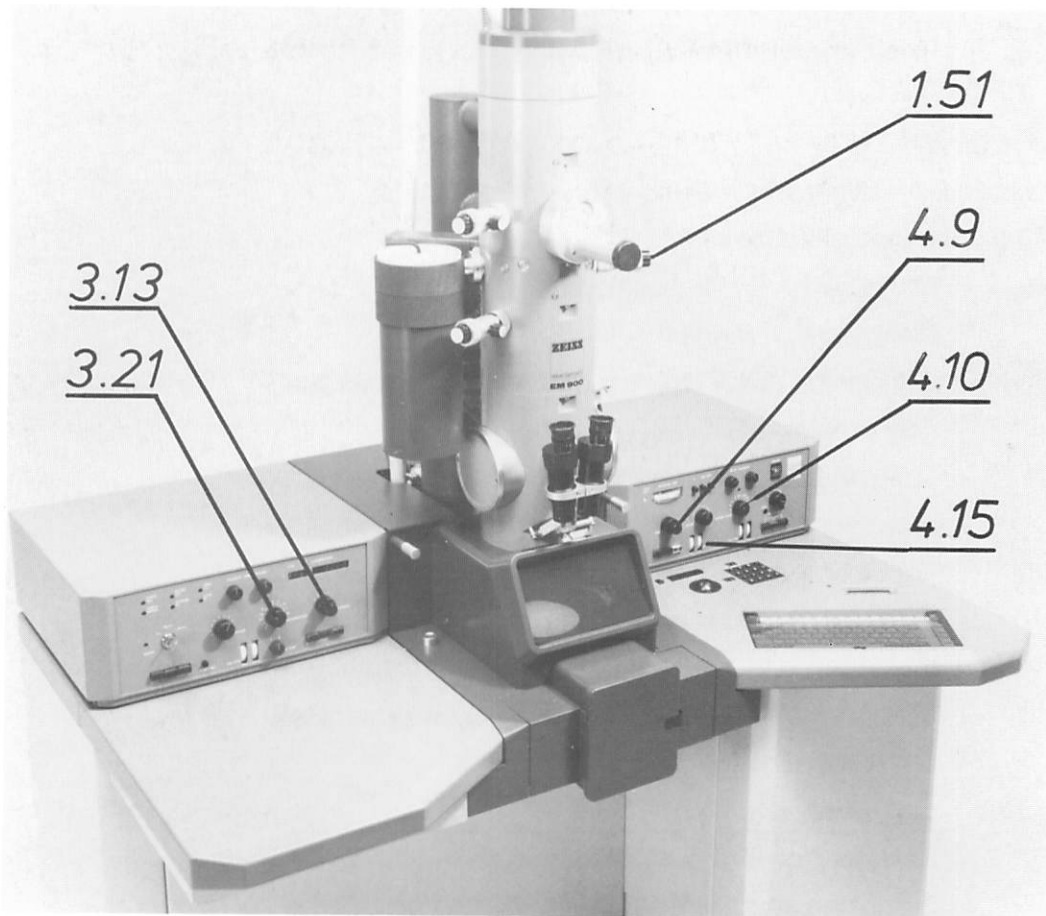


Fig.3



4. Retract objective lens aperture (1.51) from beam path.
5. Switch mode switch (4.10) to D.
6. Focus the diffraction reflections with P1 focusing control (4.9).
7. Select the camera length with step switch (3.21).

Step	1	2	3	4	5
Display	150	250	400	700	1100
Camera length (mm) = 2.6mm x display	390	650	1040	1820	2860

8. Correction of P1 astigmatism with P1 stigmator potentiometer (4.15) using the caustic pattern of the zero reflection (Fig. 3).

For exposure see Chapter 6.

5.12 Microbeam diffraction

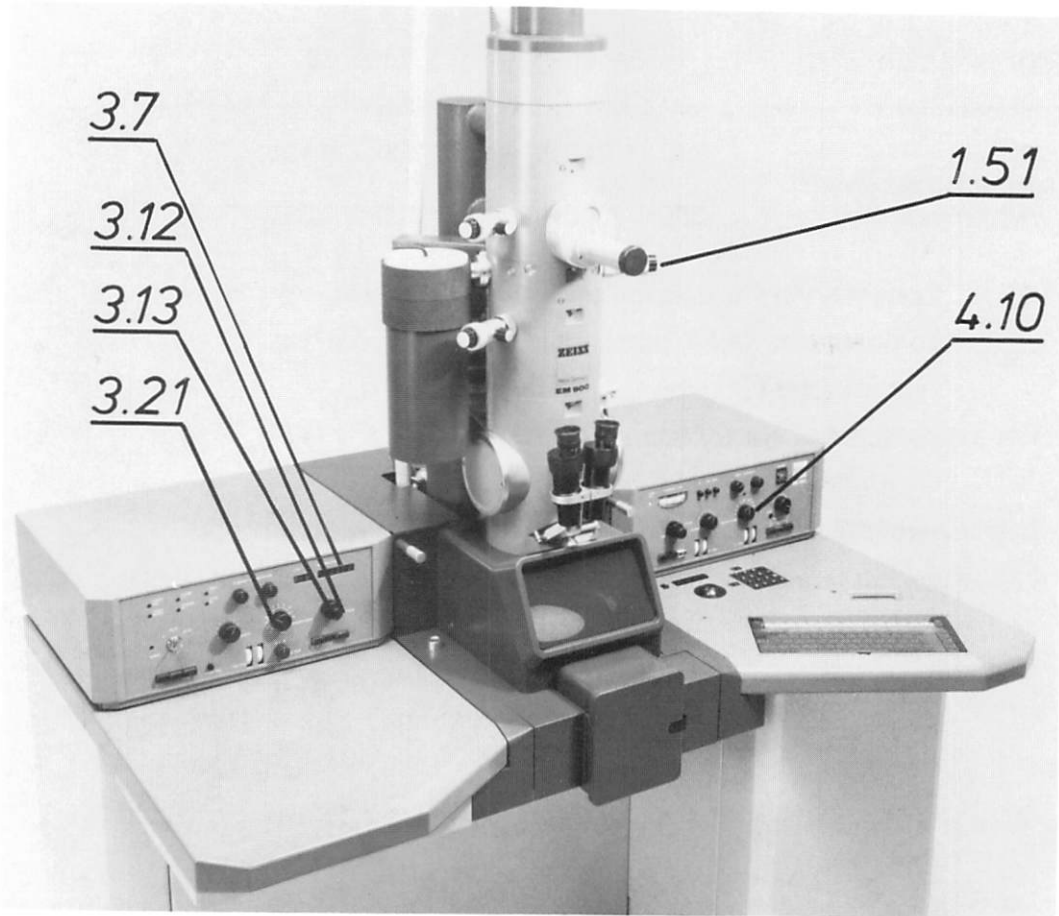
Same procedure as described under 4.41/1. to 3., but select low beam current, step 1 or 2, with (3.12).

4. Narrow condenser (3.13) as far as minimum spot: min. dia. of illuminated spot $3\mu\text{m}$.
5. Switch mode switch (4.10) to D.
6. Focus diffraction reflections with P1 focusing control (4.9).

NB: In microbeam diffraction the Airy disks become smaller with the diameter of the condenser aperture and the intensity decreases with the square of the condenser aperture diameter.

Further procedure as described under 5.9/7.

For exposure see Chapter 6.



5.13 Minimum Dose Focusing (included in base equipment)

Mode switch to MDF

Magnification display (3.7) 140000x.

Applications: exposure at medium magnifications with optimized focus, but without unnecessary radiation damage of the interesting specimen area.

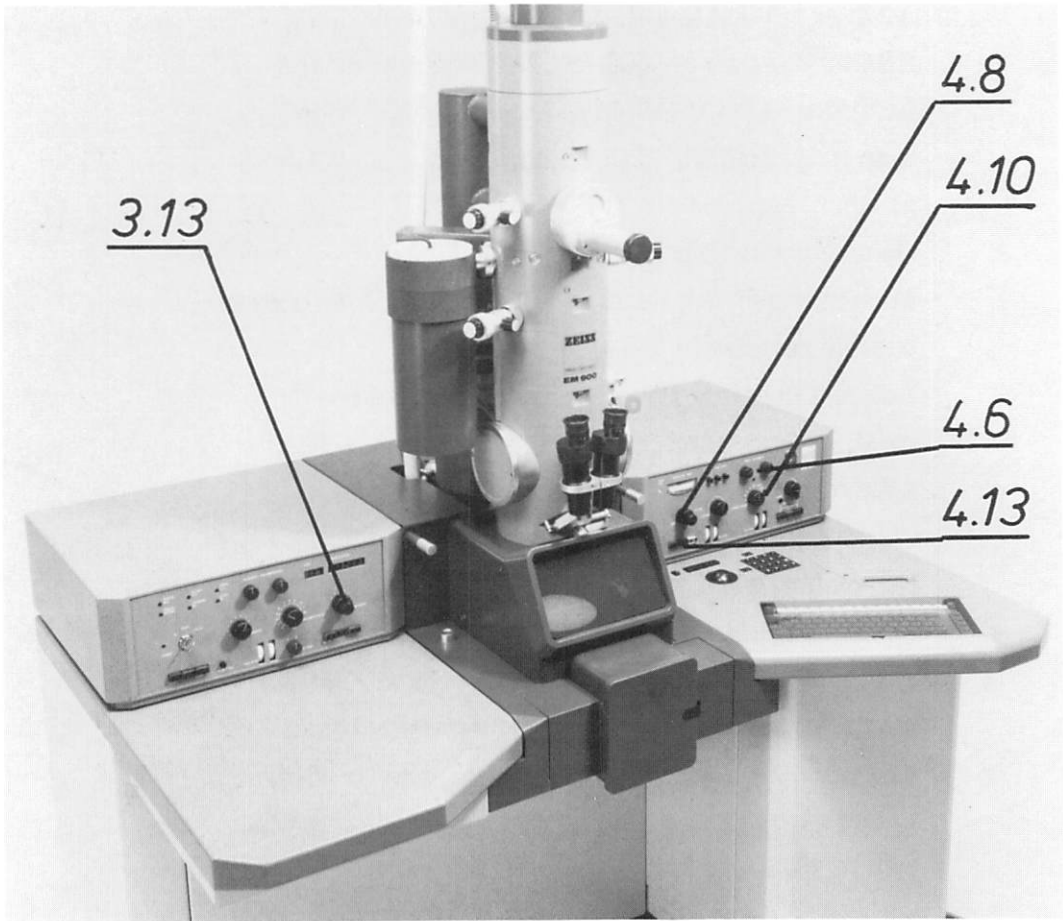
Mode switch (4.10) first to HR.

1. Condenser strongly overfocused with condenser potentiometer (3.13) turned as far as 1 to 2 turns before right stop, and low beam current (step 1 or 2) (3.12).
2. Magnification 150x (3.21).
3. Lock in specimen, center promising specimen area on fluorescent screen.
4. Adjust 3000x magnification with (3.7), insert objective lens aperture (1.51) and center it, screen specimen for interesting features at just enough brightness.

NB: Do not narrow condenser to minimum luminous spot (close to left stop) to prevent the specimen from being damaged during screening.

Center interesting specimen feature on fluorescent screen.

5. Select magnification for exposure and switch to MDF with (4.10).



6. The new specimen feature (approx. $5\mu\text{m}$ adjacent to interesting specimen feature) is now visible on the fluorescent screen at 140000x magnification and adequate brightness (the condenser is automatically focused).

Correct any displacement of the illumination with the beam alignment potentiometers (4.6).

7. Focus the specimen (4.8)/(4.13), and leave this focus unchanged.

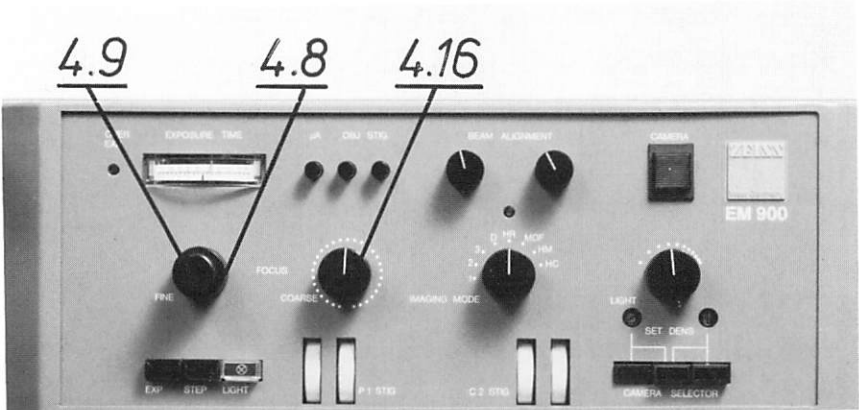
8. Switch back to HR (4.10).

The magnification for exposure is reset and the specimen feature in the center of the fluorescent screen exactly focused.

Quickly adjust exposure brightness (exposure time 1 to 2s) with condenser (3.13) and expose at once: see Chapter 6.

5.14 Magnification display by LED

The magnification display by the LED refers to the HR mode. As for the sheet film camera only a medium magnification value is displayed for each step. For the exactly calibrated magnification see the supplied table; if the demands are high, the magnification must be determined with the aid of calibrating specimens.



5.15 Magnification and magnification code for TFP camera in HR mode

Magnification table

Magnification step	1	2	3	4	5
Magnification	150	250	400	700	1100
Focusing	continuously with P1 potentiometer (4.9)				

Starting from focused step 5 focus maintained at all magnification steps 5 to 1, with constant condenser setting

Magnification code

Magnification step	6	7	8	9	10
Magnification	3000	4000	7000	12000	20000
Focusing step (nm)	960	480	480	240	120

From high to low magnifications focus (4.8)/(4.16) maintained at all magn. steps 15 to 6.

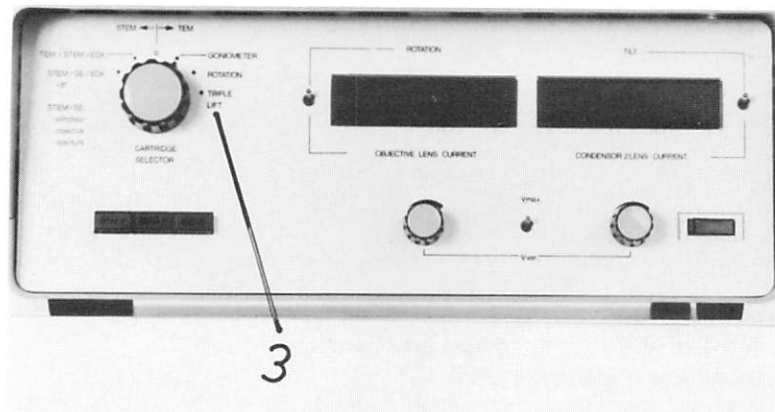
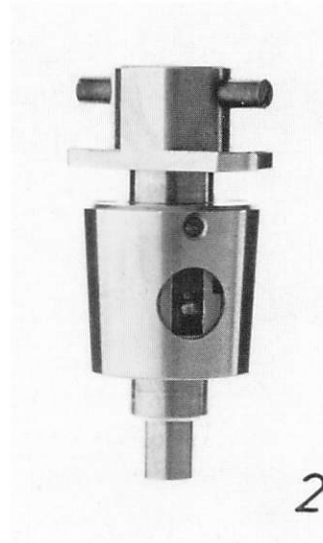
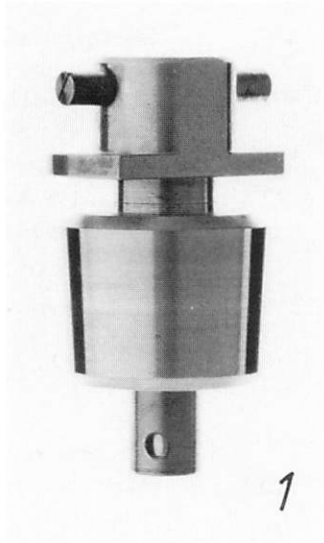
Magnification code The focusing

step is automatically matched to the magn.

Magnification step	11	12	13	14	15
Magnification	30000	50000	85000	140000	250000
Focusing step (nm)	120	60	30	15	15

Magnification code

Magnification code: The coded magnification (see table above) is imprinted on the film in large-format cameras. No decimal point coding at 50kV.



5.16 High-contrast (HC) imaging

1.0 Operating conditions

Cartridges

Required for HC mode: either short standard cartridge or lifting cartridge and topmost specimen position; lifting cartridge driven either by right-hand manual drive or goniometer control unit/LIFT mode.

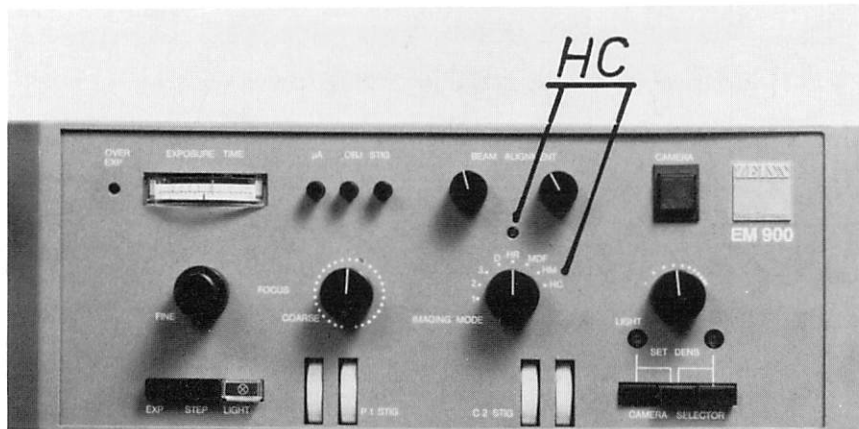
Special note: Always use cartridge and specimen position specified for HC or HR mode. No sharp image of the specimen will otherwise be obtainable!

2.0 Magnification display for sheet film camera

The digital magnification display is the same in HC and HR modes. The reduced magnification values are not separately displayed, but the correct magnification is imprinted on sheet film.

HC mode: 165, 275, 440, 770, 1210,
1200, 1760, 2800, 4800, 8000,
12000, 20000, 34000, 56000, 100000x.

Fix-focus when changing the magnification in the ranges from 100000x to 1200x or 1210x to 165x.



3.0 Magnification display for TFP camera

The digital magnification display is the same in HC and HR modes. The reduced magnification values are not separately displayed, but light in the lamp on top of the mode switch displays that the special HC mode is operative.

3.1 Magnification values

Magnifications in HC mode:

Magnification range I: all displayed magnifications approx. x 1.1*)

Magnification range II and III: all displayed magnifications approx. x 0.4*)

*) For exact factors see the annex to the magnification table.

3.2 Film data code

Pictures taken in HR mode feature a decimal point between 4-digit frame number and magnification code, those taken in HC mode do not.

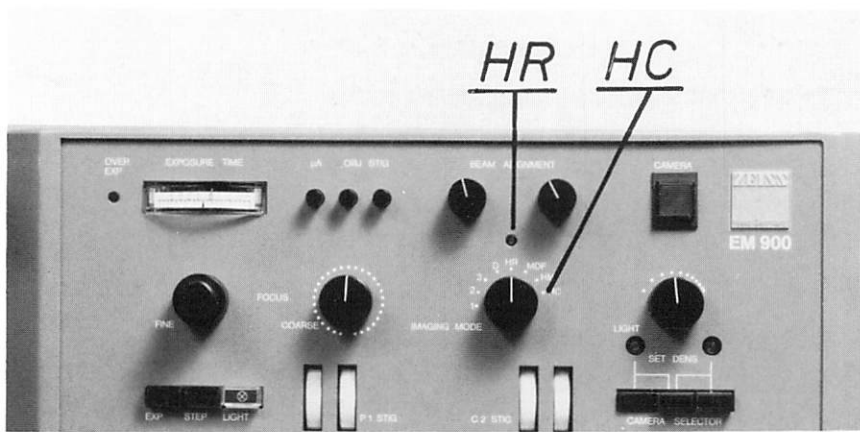
Example:

3 . 0078 . H

without decimal point: HC mode 20000x0.4
with decimal point: HR mode 20000x

3.2.1 35mm camera

The exposure sequence for the 35mm camera must be written down!



3.3 Zoom magnification

Fix-focus accuracy during magnification change is the same in HC and standard HR modes, i.e. the fix-focus is valid from III/5 (250000x0.4) to II/1 (3000x0.4) or I/5 (1100x) to I/1 (150x).

3.4 Useful magnification range in HC mode

Mainly the magnification range II, because there the HC magnifications annex directly to the magnification range I.

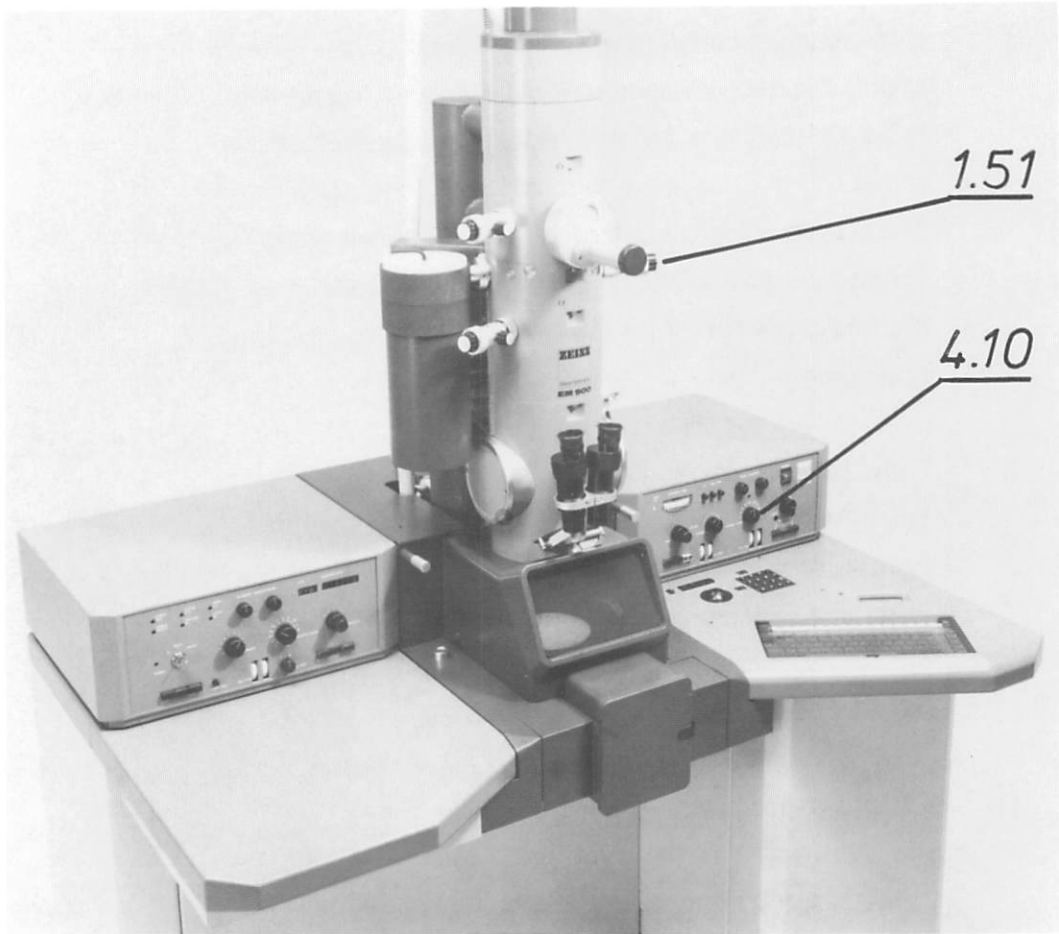
The standard focal length (HR) at 80kV accelerating voltage is preferable for high magnifications at highest resolution or for the imaging of thick specimens.

3.5 Correction of astigmatism

It is different in HC and HR modes. When changing between the two modes the astigmatism must always be corrected with the stigmator potentiometer at the highest possible magnification. Optimized adjusting values are displayed in TEST mode.

3.6 Objective lens aperture

An 180 μ m single-hole aperture is required for imaging in the magnification ranges II and III without cutoff of the image. Smaller apertures (90, 60, 30 μ m) may cut off the image when condenser lens 2 is overfocused.



3.7 Operation

Switch on instrument and align as described in the brief operating instructions. Load specimen in short standard cartridge or in lifting cartridge and lock it in.

A specimen in a lifting cartridge is brought into limit position with the motor drive or manually.

Set mode switch (4.10) to HC, magnification to 3000x (1200x), insert 180 μ m objective lens aperture (1.51) and center it with reference to the large fluorescent screen. Centration is impossible in D mode. Therefore, shift the objective lens aperture using one drive until the aperture edge is visible first on one and then on the other side. The shift distance is averaged and the same procedure followed for the second drive.

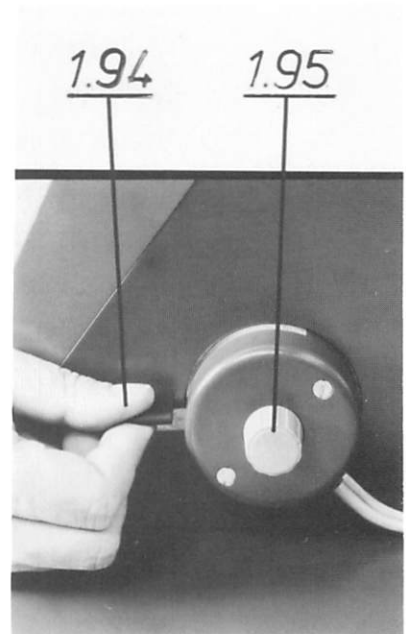
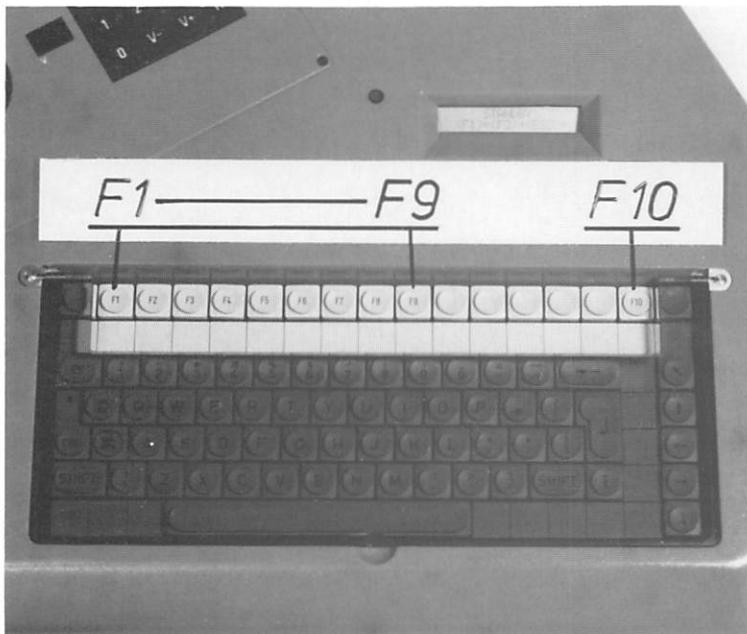
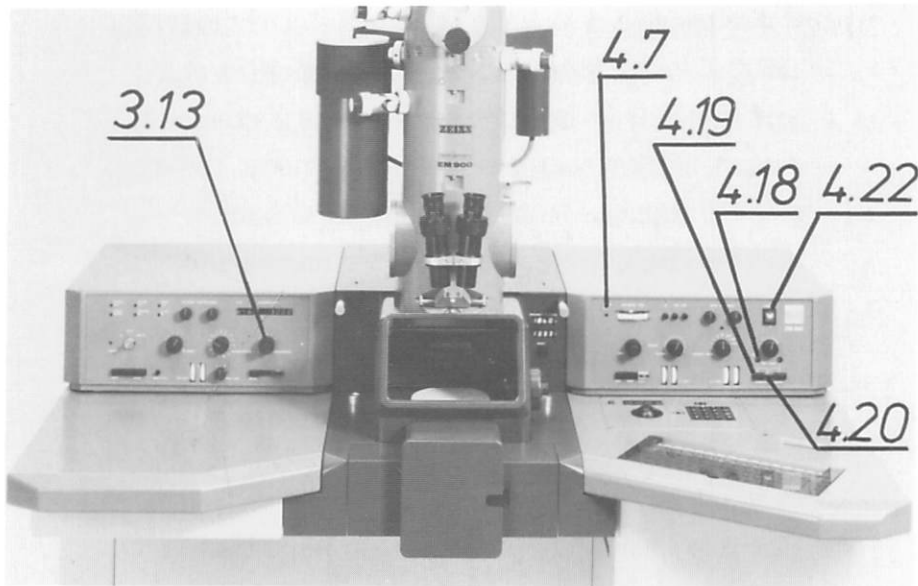
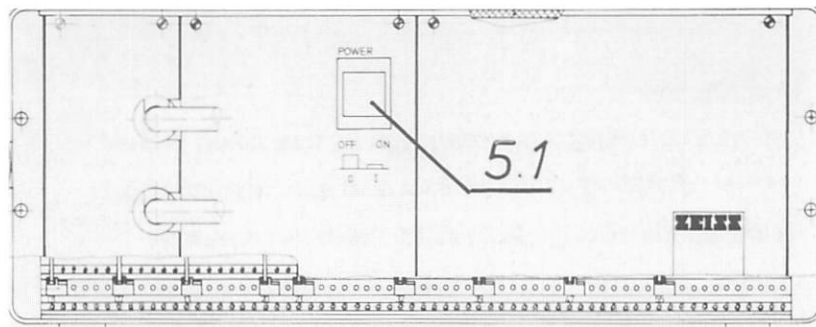
3.8 Imaging specifications for HC-HR modes

Electron-optical data (magnification steps 15-6)

Mode	HC	HR
Objective lens focal length		
fo (mm)	6.25	2.6
Spherical aberration		
constant Cs (mm)	13.5	2.3
Chromatic aberration		
constant Cc (mm)	5.1	1.7
Obtainable lattice resolution		
(80kV/ <6mGpp) (nm)	0.9	0.344

The electron-optical conditions are identical in both modes in the magnification range with the steps 1-5.

5.28



Chapter 6: Operation of sheet film camera

6.1 Sheet film camera (single exposures)

Switch on EM 900. The camera is automatically switched on when the POWER key on the power supply (5.1) and the CAMERA key (4.22) are held down.

LCD displays "STANDBY"

(F1)*(F2)*(ESC)*

Depress F1 for single exposure mode.

Input/display of camera data

F1 Input of user identification and change of frame number

F2 Free input of 6 + 16 alphanumeric characters

F3 Display of instrument parameters

F4 Input of film reserve

F5 Input of data imprint

F6 Standby; change between F1 and F2 modes possible

F8 Information about cassette type (1.5mm or 3mm)

F7, F9, F10 are functionless in single exposure mode

Depress (4.19) on the EM for camera selection 60/70.

Film speed setting: with potentiometer (4.18) on the EM

by simultaneously depressing TEST key (4.20).

Exposure measurement is made on the focusing fluorescent screen.

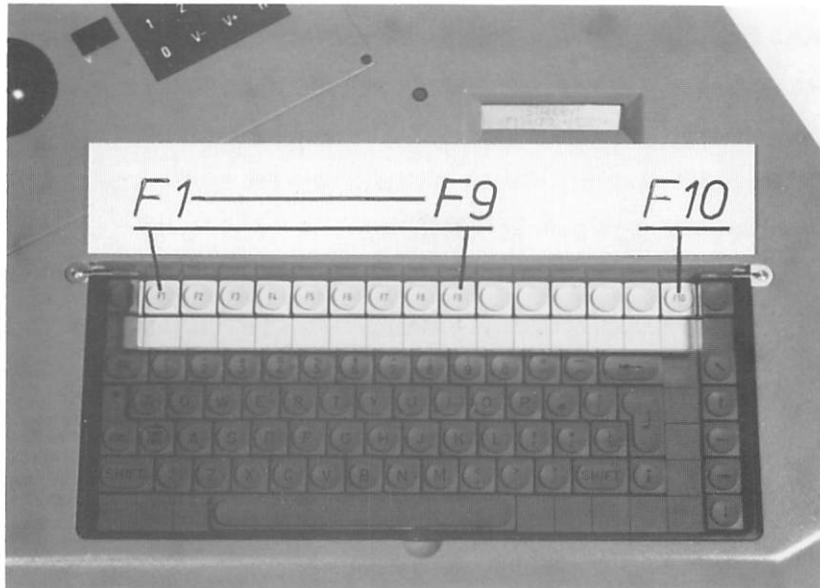
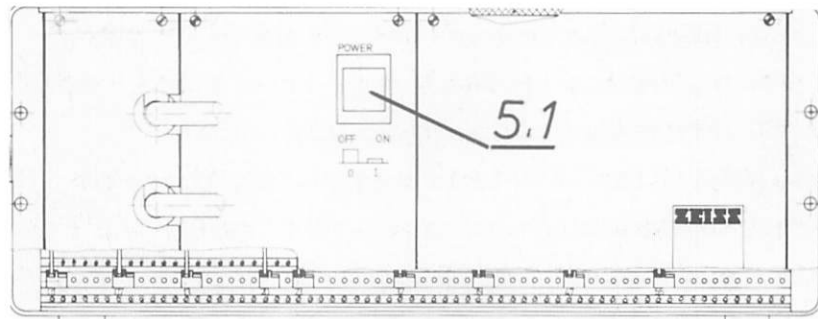
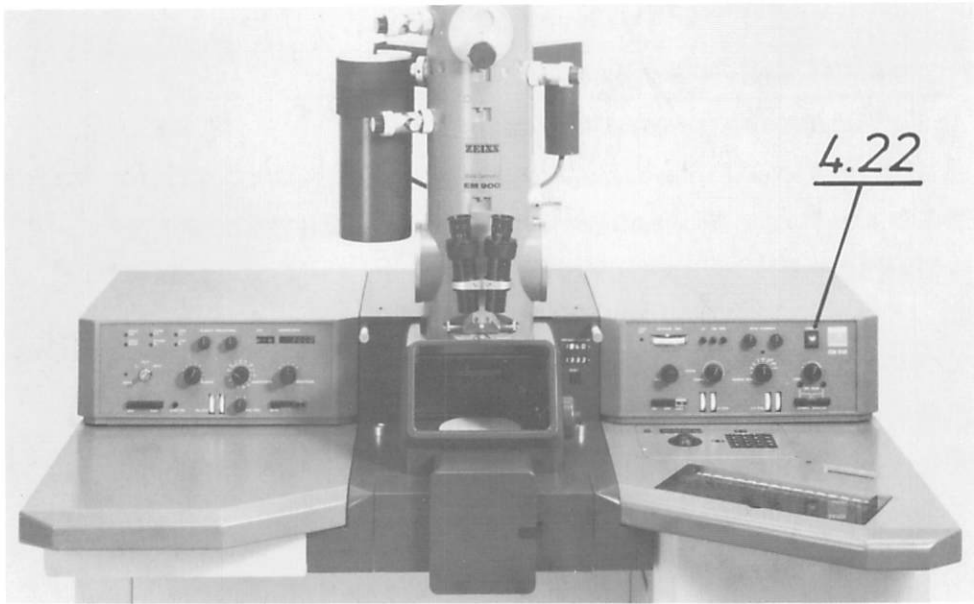
Exposure time: adjust image brightness with BRIGHTNESS control (3.13) on the EM until the lamp in OVER EXP (4.7) goes out and the photographic format is fully illuminated.

For correct measurement of the exposure time the small fluorescent screen (1.95) must be completely swung down (left limit stop).

Search specimen feature and focus.

Release exposure by raising the fluorescent screen (1.94). The exposure is automatically started. (Depress the exposure START key on the EM only for roll film cameras.)

5.29



6.2 Sheet film camera (serial exposures)

Switch on EM 900. The camera is automatically switched on when the POWER key on the power supply (5.1) and the CAMERA key (4.22) are held down.

LCD displays "STANDBY"

(F1)*(F2)*(ESC)*

Depress F2 for serial exposure mode.

Input/display of camera data

F1 Input of user identification and perhaps of frame number

F2 Free input of 16 alphanumeric characters (lower line only)

F3 Input of instrument parameters

F4 Input of film reserve

F5 Input of data imprint

F6 Standby, change to F1 mode possible

F7 It must be pushed once for display of the measured electron current and the calculated exposure time, and pushed twice for input of the negative density.

F8 Information about cassette type (1.5mm or 3mm)

F9 The target current is written into the last 6 digits of the upper line of the main menu and imprinted. The current value is maintained until it is overwritten again, a means to record the target current.

F10 Exposure start

6.3 Photography

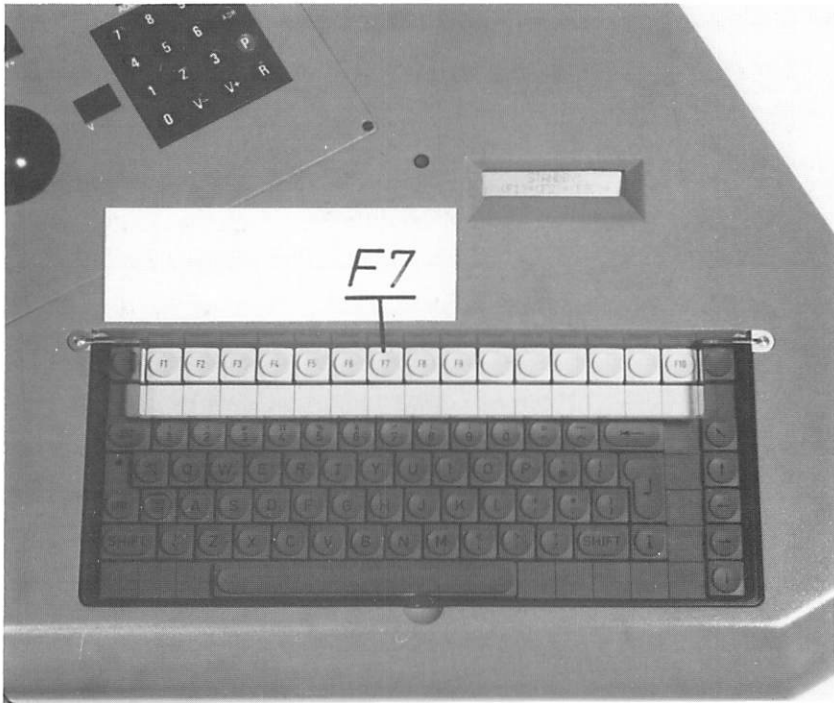
Search for a specimen feature and focus.

Raise fluorescent screen.

Check of exposure time with F7. Integral exposure measurement over the entire negative format.

Depressing F10 releases automatic exposure measurement and exposure control.

Swing down fluorescent screen after the last exposure.



6.4 Film speed and exposure with the sheet film camera

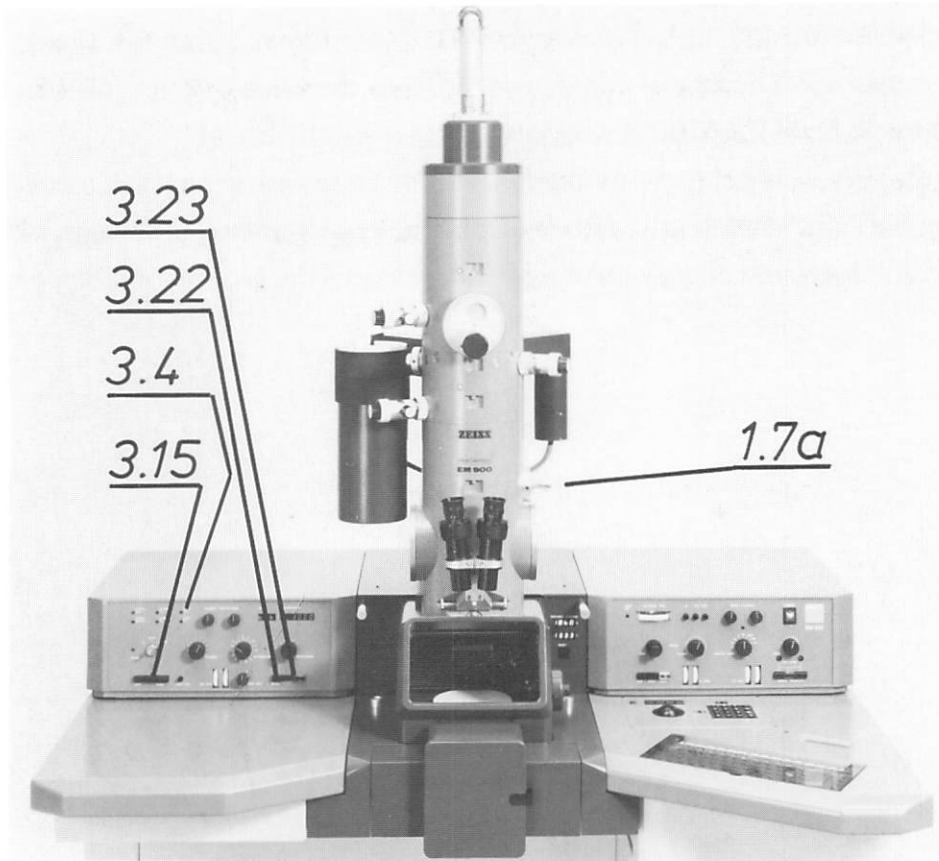
The speed is defined as follows (Kodak): an exposure of $1/q$ electrons/square micrometer is required to obtain a density of 1.00 above fog level (see at bottom of the first page on slip for SO 163 film, KP 77769a 7-82). For the sheet film camera of the EM 900 the film density (not the film speed!) is input in electrons/square micrometer $el/\mu m^2$ (display: $el/q\mu m$) in serial exposure mode.

Example:

Kodak film SO-163. Kodak development D 19 for 12min., given film speed: 2.2 (Kodak).

To obtain a film density of 1.00 above fog level, the value $1/2.2 = .45el/q\mu m$ must be input with FILM EXPOSURE (depress function key F7 twice).

As the density is generally proportional to the exposure when a film emulsion is exposed by electrons (at least within more or less extended regions of the characteristic curve) the desired density can be given by input of the proportional film exposure.



6.5 Film exchange

Close valve V3 (1.7a) and depress key VENT CAM (3.15): the camera is ventilated.

Important note: Open the camera only in ruby light. Take out container with exposed films and load it in light-tight transport container. Close lid.

Exchange the empty for a magazine loaded with film.

Important note: Use only pre-dried film material.

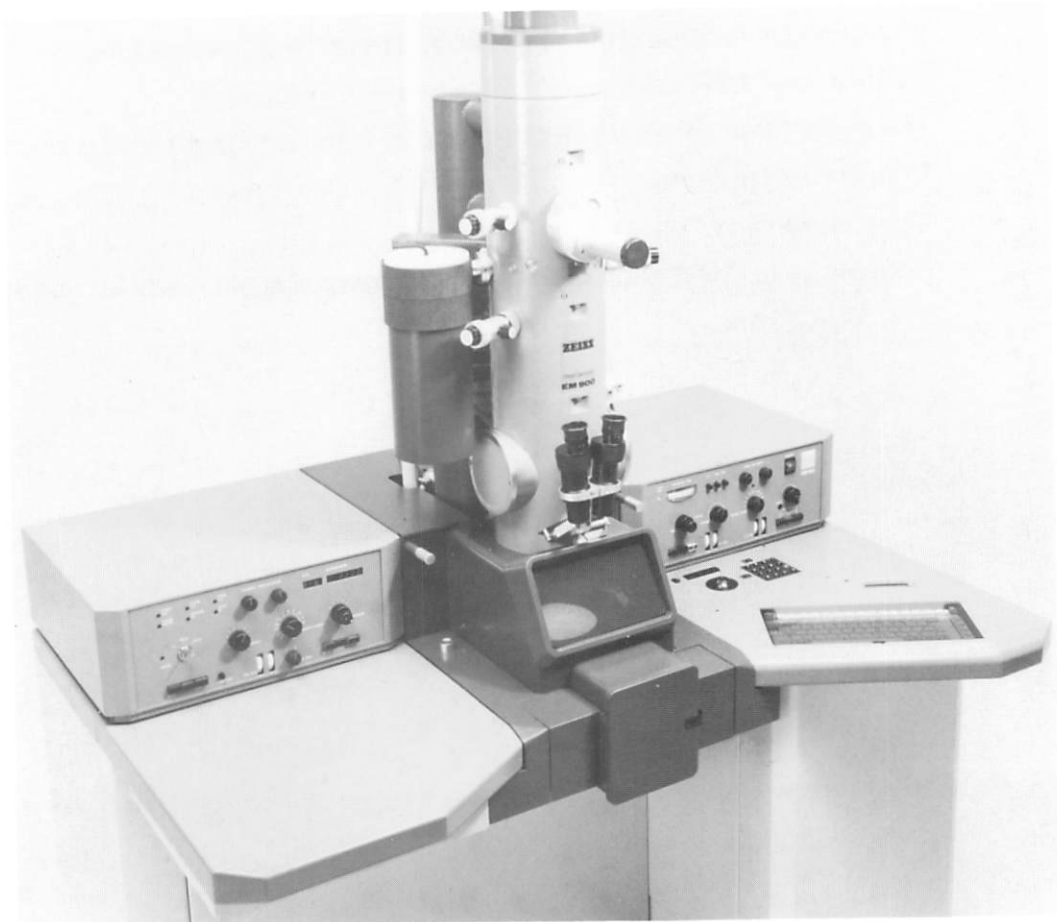
(Pre-drying is recommended in desiccator with nitrogen ventilation.)

Depress key VENT CAM again: the camera is evacuated.

The signal lamp OPEN V3 (3.4) will display high-voltage go-ahead after 2 to 3min. if the films are well pre-dried.

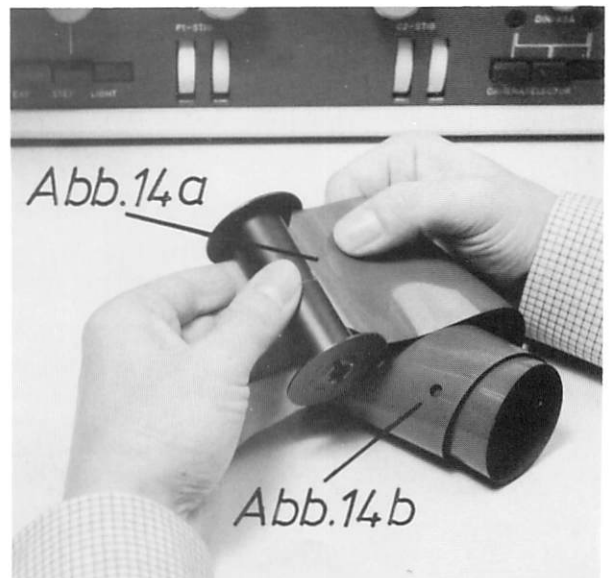
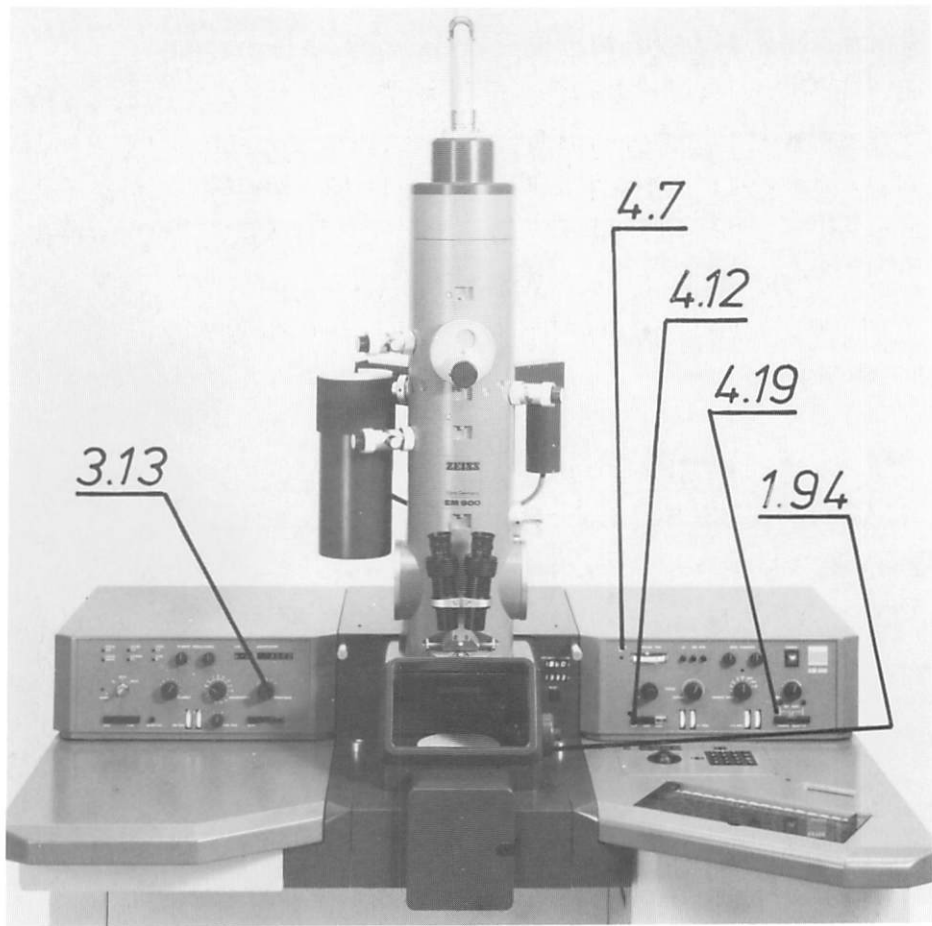
Open valve V3 (1.7a).

Depress keys (3.22) and (3.23). The instrument is again ready for operation.



6.6 Film material, exposure and development (as of Oct. 1986)

Camera	Application	Film type	Development	Exposure for D=1 (el/ μ m ²)
Sheet film camera EM 900	Brightfield, darkfield	Kodak SO 163 3 $\frac{1}{2}$ x4"	Kodak D 19 1+2 4' 20°C	1.25
	Brightfield with high re-enlarge- ment	Kodak 4489 3 $\frac{1}{2}$ x4"	Kodak D 19 1+2 4' 20°C	3.0
	Low Dose	Kodak SO 163 3 $\frac{1}{2}$ x4"	Kodak D 19 conc 12' 20°C	0.6
TFP camera EM 900	Brightfield	Agfa Aviortho 25, 70mm, by the meter (30m)	Agfa Rodinal 1+20 4' 20°C	11
		Kodak techni- cal panfilm 2415 by the meter (45m)	Kodak HC 110 solution D 6' 20°C	5
		Kodak techni- cal panfilm 6415 type 120	Kodak HC 110 solution D 6' 20°C	5
		Ilford Pan F type 120	Agfa G5C 1+5 5' 20°C	7
		Agfapan 100 type 120	Agfa G5C 1+5 20°C	3.2
	Color slides	Agfachrome 50 S type 120	by Agfa	4
		Ektachrome 64 type 120	by Kodak	3.5
35mm camera EM 900	Brightfield, darkfield, Low Dose	Kodak techni- cal panfilm 2415, 135-36	Kodak D 19 1+2 4' 20°C	
		Agfaortho 25 135-36	Agfa Rodinal 1+10 4' 20°C	
	B/W slides	Agfa Dia direct 135-36	by Agfa	
	Color slides	Kodachrome 25, 135-36	by Kodak	



Chapter 7: Operation of TFP camera

For photography depress camera selector 60/70 (4.19). With condenser potentiometer BRIGHTNESS (3.13) select the image brightness: the lamp OVER EXP (4.7) must go out and the photographic format be fully illuminated. The small fluorescent screen must be swung down. Raise the large fluorescent screen with lever (1.94) before you expose. Depress the key START (4.12) and wait until the light in this key goes on again. Swing down the fluorescent screen slowly and press lever (1.94) down until it snaps in: the light in the START key goes out. If the light in the key is ON the shutter is closed.

7.1 Exchange of film in TFP camera

Load film (may be done in daylight) (Fig. 14).

1. Retract right resilient peg, plug take-up spool on driving shaft (to check the meshing turn it until you feel resistance), and let the resilient peg snap in.
2. Load the feed spool on the left side accordingly. The leader is guided from below over the negative carrier.
3. Pull leader to the right over the negative carrier and thread trimmed end into slot of take-up spool (14a).
4. Advance leader by pushing the key MOTOR SET until the leader mark becomes visible: 60mm film type 120/220 is marked with a triangle visible on a mirror, user-made 70mm film with leader and trailer with a circle (14b).

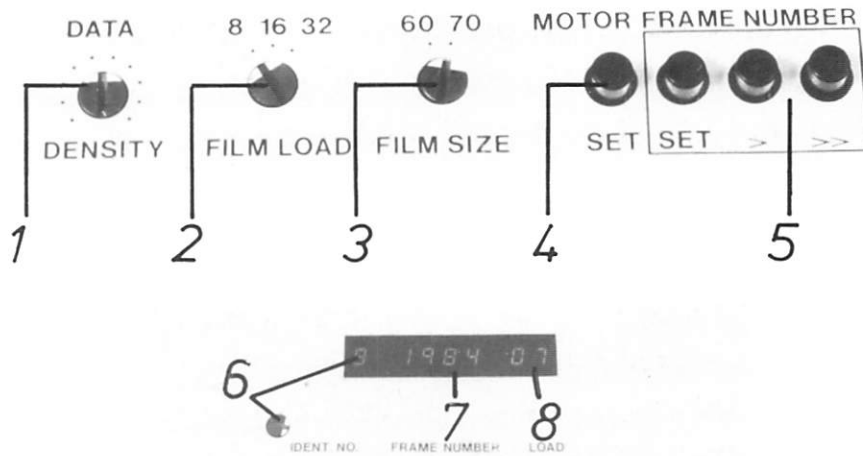


Abb. 15

- 1 Datenschwärzung
- 2 Film-Vorrat (eingelegt)
- 3 Film-Format
- 4 Motorvorlauf (manuell)
- 5 Aufnahmenummer-Einstellung
- 6 Kennziffer (einstellig)
- 7 Aufnahmenummer (4stellig)
- 8 Film-Vorrat

Abb. 15

- 1 Data density setting
- 2 Unexposed film (loaded)
- 3 Film format
- 4 Motor run (manual)
- 5 Number of frame setting
- 6 Identification number (1 digit)
- 7 Frame number (4 digits)
- 8 Unexposed film

7.2 Programming of TFP camera electronics (Fig. 15)

1. Settings according to film width and length

Film type	FILM SIZE	FILM LOAD	DATA DENSITY
120	60	8	dependent on
220	60	16	film speed;
user-made	70	8/16/32	determined by density test series

2. Setting of consecutive number with FRAME NUMBER: required only for start of film numbering from 0000 (e.g. at the beginning of the year) or re-setting of lost consecutive number after instrument switch-off because of exhausted battery. Fast run: depress the keys FRAME NUMBER and > >. Slow counting: depress FRAME NUMBER and > >.

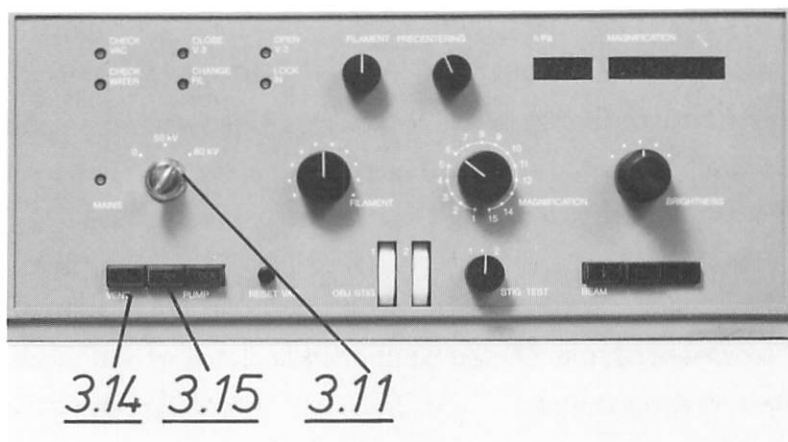
7.3 Closing the camera adapter

NB: The camera adapter should be opened and closed only when the instrument is ON; otherwise no programming.

1. Raise camera adapter in front to override the stop and slide it back all the way.
2. Turn lever fully anticlockwise: the camera adapter is raised, the film leader runs automatically and the film data flash.

NB: Do not open the lever while you close the camera adapter or afterwards! This would again advance the leader and reduce the film reserve by the length of the leader! The end of the leader is reached when the displayed film data (FRAME NUMBER,) light continuously.

3. Readiness: the TFP camera is ready for exposure when the end of the leader is reached.



Chapter 8: Description and operation of the vacuum system

8.1 Vacuum system of the EM 900

The vacuum system comprises a high-performance turbomolecular pump with a capacity of 170l/s and a two-stage rotary pump with a capacity of 8m³/h.

A 200 μ m throttle valve divides the electron-optical column into two separate vacuum areas.

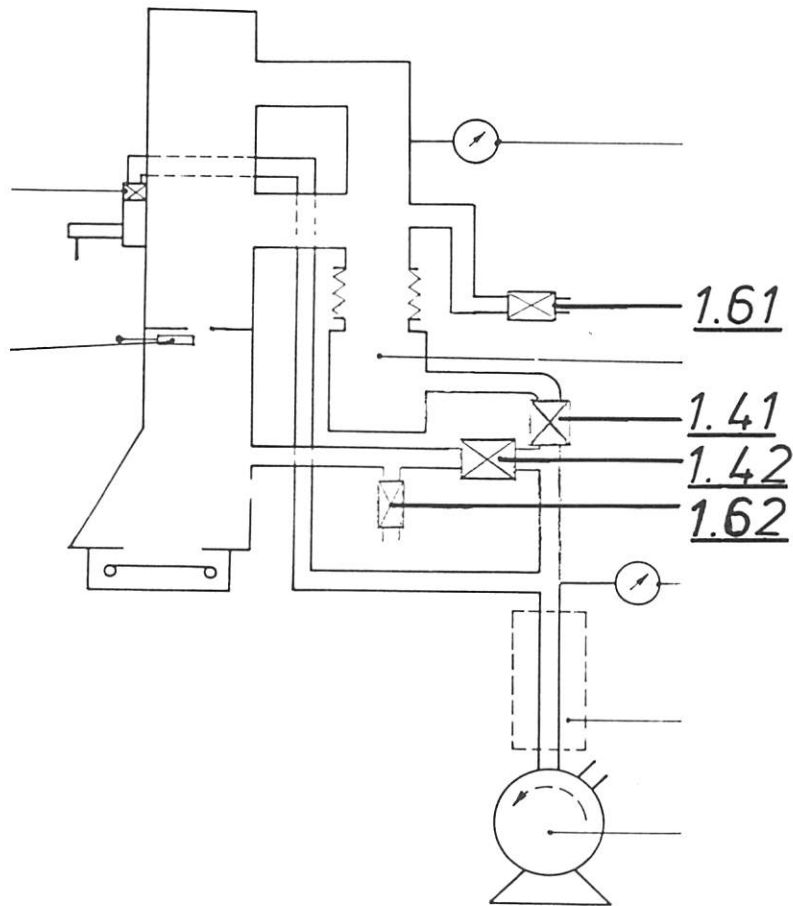
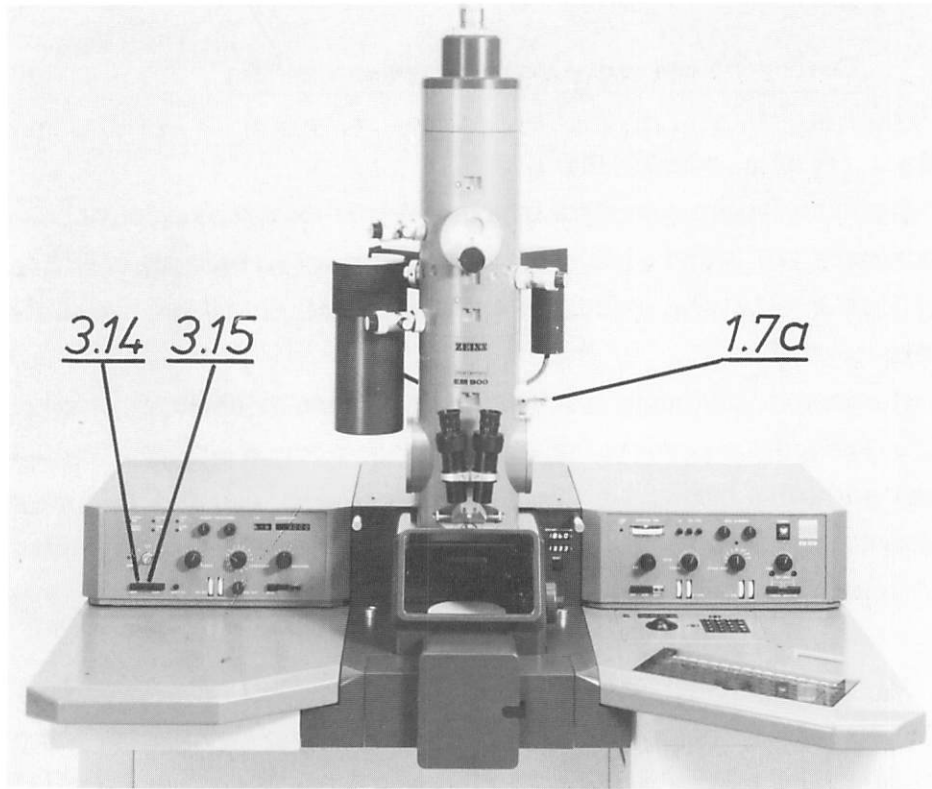
The turbomolecular pump evacuates the high-vacuum chamber which contains the cathode head, the specimen chamber and the electron optics, to 2x10⁻⁶mbar. The lower part of the column which contains the viewing head and the camera chamber, is evacuated to 1x10⁻²mbar by the rotary pump. The entire vacuum system is controlled automatically and failsafe by a microprocessor system, which guarantees an oil-free high vacuum (for more information see Chapter 7).

8.2 The camera chamber must be pumped down first for ventilation of both vacuum chambers. If the key VENT COL (3.14) is depressed, the lamp VENT CAM (3.15) flashes, displaying that the camera chamber must be evacuated first.

If the camera chamber is evacuated, pump-down of the column can be started if a pre-vacuum of 1x10⁻¹mbar has been obtained in the camera chamber. If this point is achieved, the lamp in VENT COL (3.14) will flash, it stops flashing after 1 minute.

8.3 Power failure

In case of power failure the entire system is shut down and all valves are closed. After a delay of 1 to 2s the instrument will be flushed for approx. 1s. The pump program will restart from the very beginning when the power is switched on again. The pump program will start automatically if the key switch (3.11) is in position I or II.



8.4 Ventilation of column (e.g. for filament exchange)

Depress key VENT COL (3.14). If the ventilating program is started, the lamp in VENT COL (3.14) goes on.

V3 (1.7a) must be closed for ventilation of the column.

High-vacuum measurement and turbopump are switched off and the angle valve of the turbopump (1.4.1) is closed. The ventilating valve (1.6.1) is opened and the column ventilated.

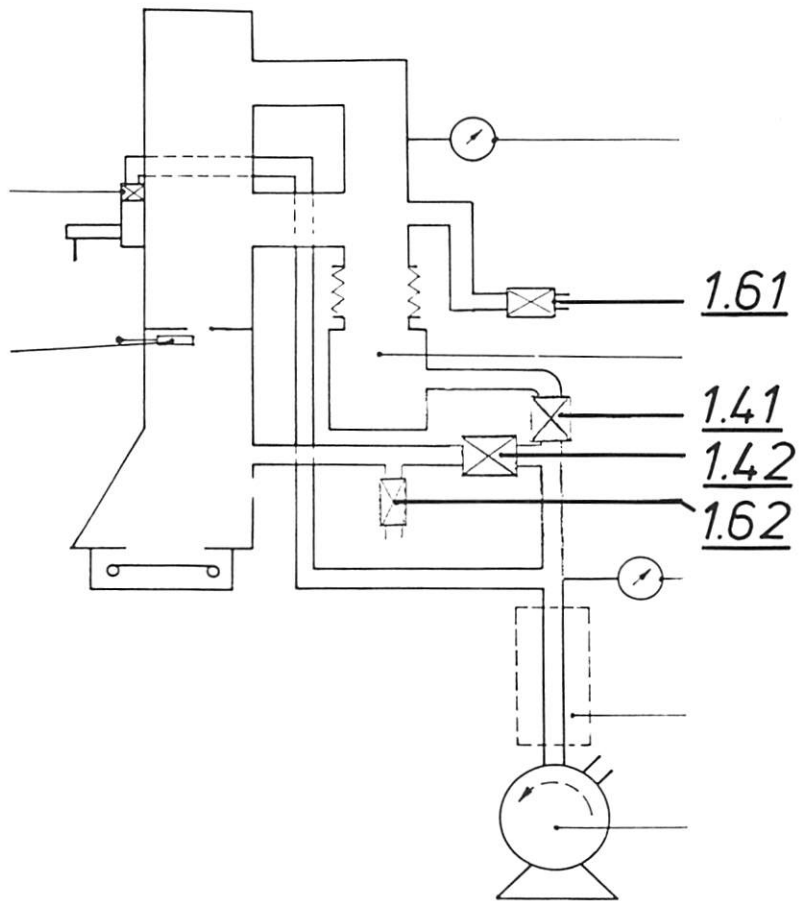
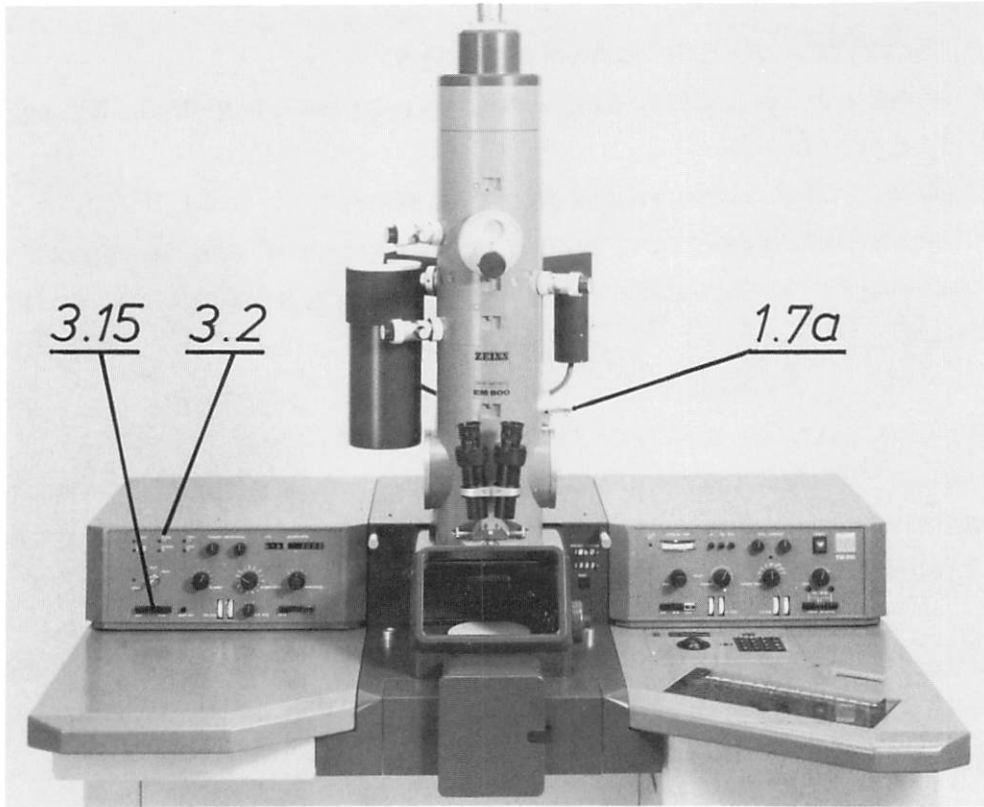
8.5 Pump-down of column

Depress key VENT COL (3.14). The lamp in the key goes out and the ventilating valve of the column (1.6.1) is closed. The angle valve of the camera (1.4.2) is closed and the pump program continues as described under 6.2.4.

8.6 Ventilation of camera chamber (e.g. for film exchange)

Depress VENT CAM (3.15). The lamp in VENT CAM (3.15) goes on when the ventilating program is started. V3 (1.7a) must be closed for ventilation of the camera. The camera angle valve (1.4.2) is closed. The camera ventilating valve (1.6.2) is opened and the camera chamber ventilated.

5.37



8.7 Pump-down of camera chamber

Depress key VENT CAM (3.15). The lamp in VENT CAM (3.15) goes out and the camera ventilating valve (1.6.2) is closed.

The turbopump angle valve (1.4.1) is closed and the camera angle valve (1.4.2) opened. The turbopump angle valve (1.4.1) is opened again when the vacuum of 1×10^{-1} mbar is obtained. The pump program continues as described under 6.2.6. The pump time is dependent on the amount of film and the pre-desiccation time.

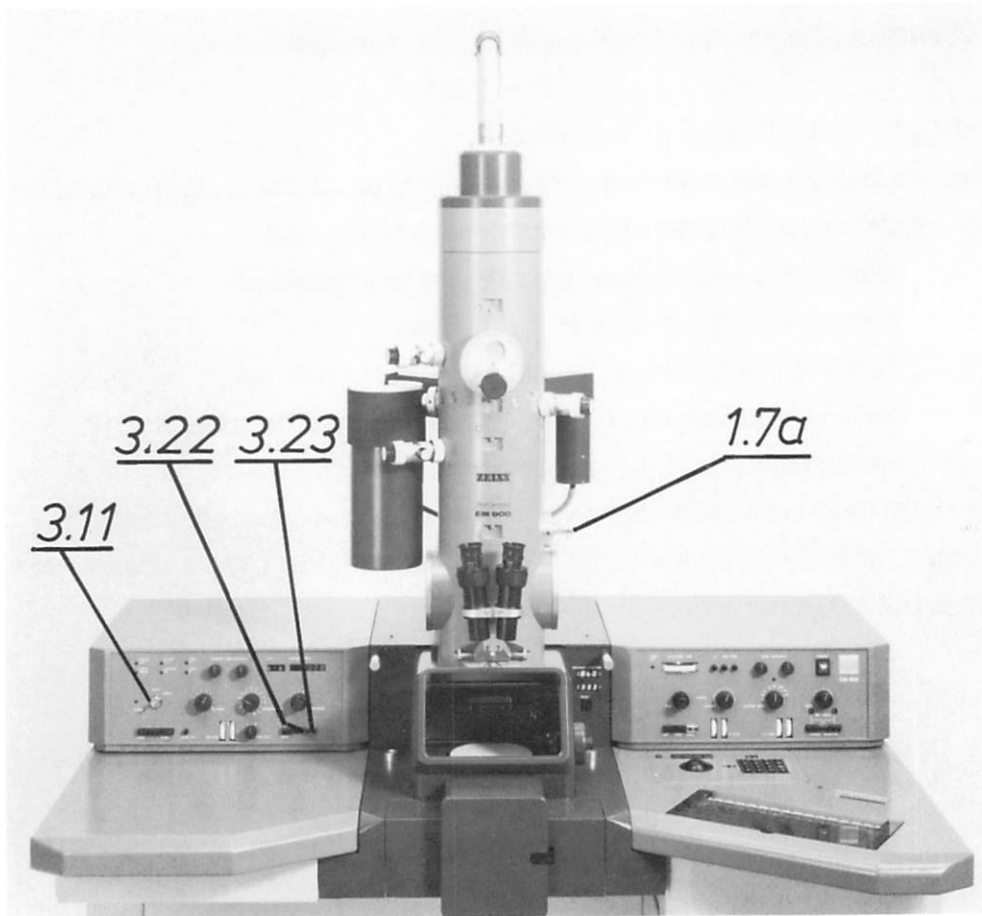
8.8 Ventilation of both vacuum chambers

The two vacuum chambers can only be ventilated successively, not simultaneously.

- a) When the ventilation of the camera chamber was started, the column can only be ventilated when the camera ventilating valve (1.6.2) is open.
- b) When the ventilation of the column was started, the camera chamber can only be ventilated when the column ventilating valve (1.6.1) is open.

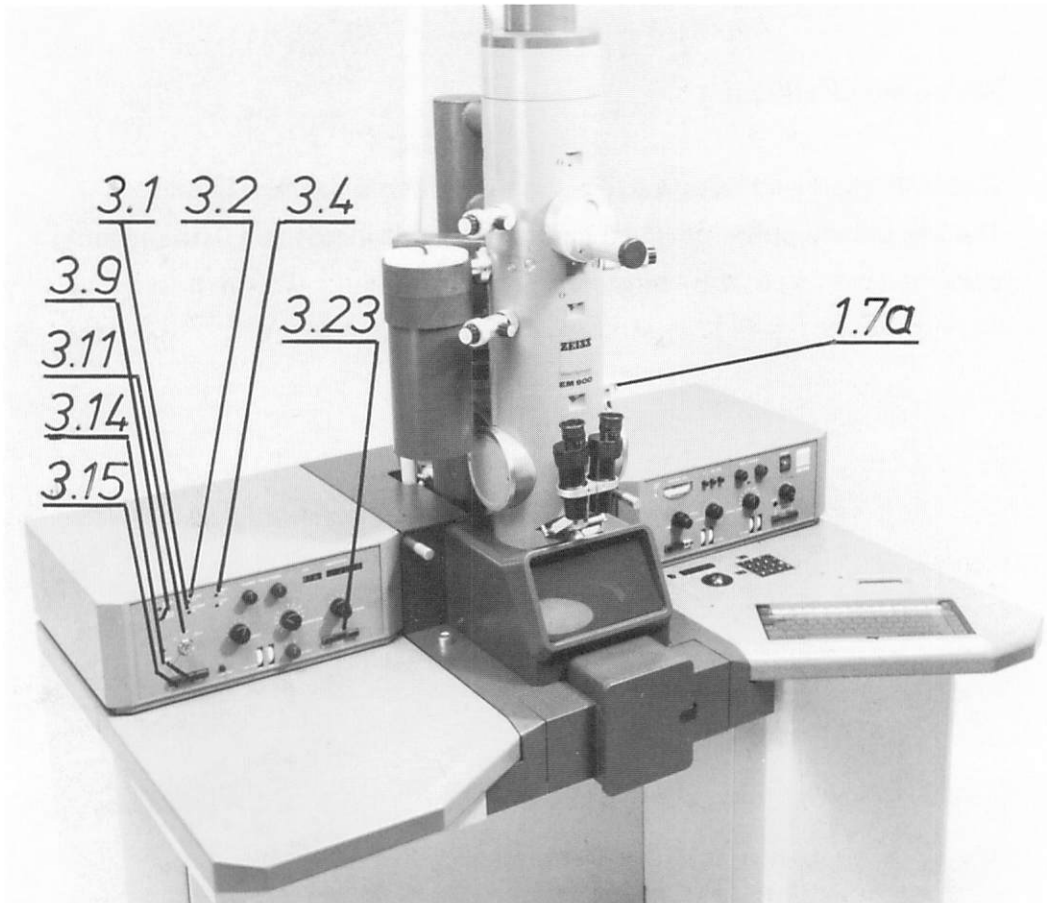
V3 (1.7a) must be closed for the ventilation of both vacuum chambers.

Special note: The lamp in CLOSE V3 (3.2) flashes if V3 (1.7a) is opened in ventilated state, but the pump program will not start.



Chapter 9: Instrument switch-off

- 9.1 Switch off filament (3.22) and high voltage (3.23).
- 9.2 Close valve V3 (1.7a).
- 9.3 Key switch (3.11) to 0.
- 9.4 Close nitrogen ventilating valve when the instrument is flushed.
The key can be pulled off when the key switch is in position 0, to prevent unauthorized use of the instrument.



Chapter 10: Displays for establishment of normal operating conditions

Either of the 4 red warning lamps displays extraordinary operating conditions: execution of the displayed "instruction" will re-establish normal conditions.

10.1 CHECK WATER (3.9) lights

It lights only when key switch (3.11) is in position 50kV or 80kV and displays lack of water supply or water supply failure. The lens currents are automatically switched off, no image (the same appears if the lens currents are switched off or fail).

Remedy: 1. re-establish water supply, 2. turn key switch (3.11) first to 0 and then back to 50kV (or 80kV).

10.2 CHANGE FIL (3.1) lights

When key (3.23) is depressed and the lamp in the key lights the filament is burnt out.

Remedy: exchange filament (Chapter 7, page 7.2).

10.3 CLOSE V3 (3.2) lights and flashes

Possible reasons:

1. Valve V3 (1.7a) opened before the lamp in OPEN V3 (3.4) lights and displays go-ahead.
2. Sudden pressure increase in camera chamber (e.g. degassing of film).
3. Key VENT COL (3.14) or VENT CAM (3.15) is depressed but valve V3 (1.7a) open.
4. Key switch (3.11) was turned to 0 but valve V3 not closed.

Remedy: Close valve V3 manually.



3.6

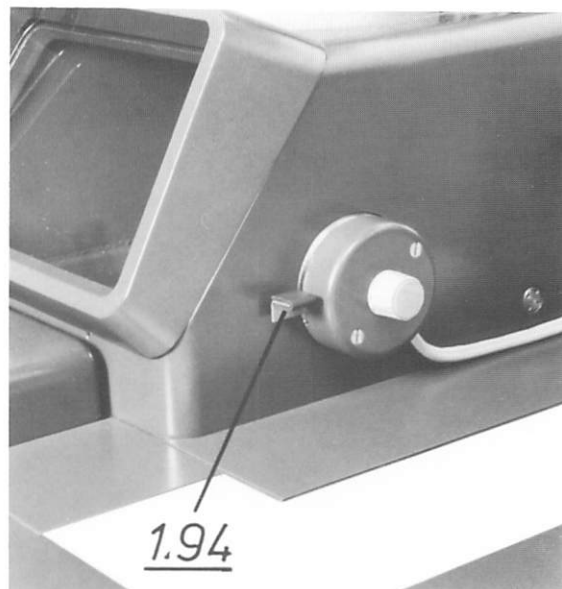
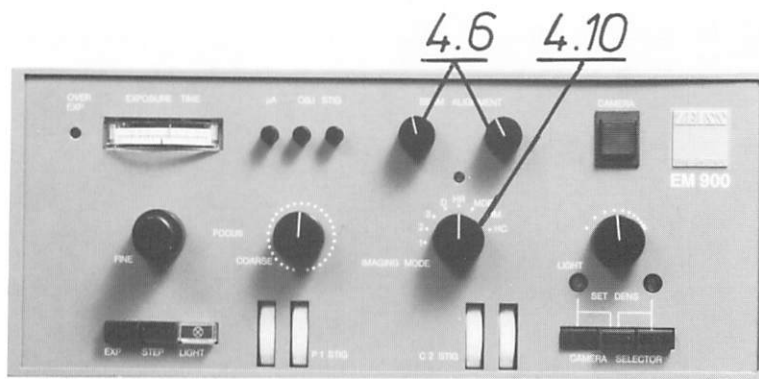
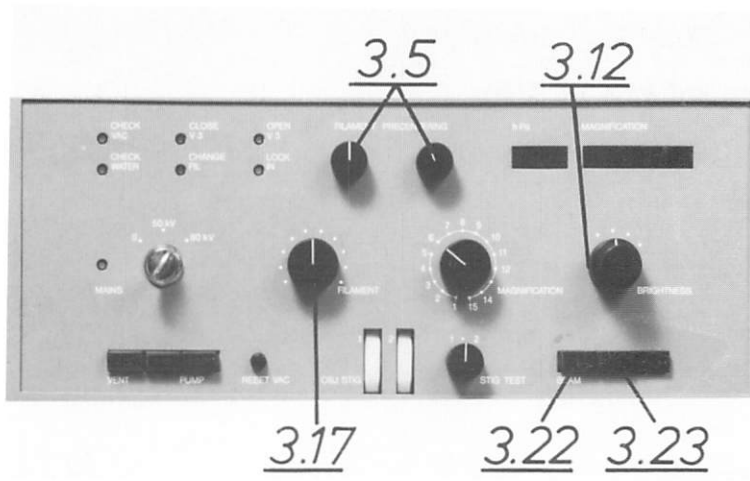
RESET VAC

10.4 **CHECK VAC (3.6) lights**
and the vacuum display displays an operating condition (see Chapter 7.0 (Microprocessor-controlled vacuum system)).

10.5 **RESET VAC**
Depressing the RESET VAC key releases a reset of the pump control program which can be used to reset the display of the operating conditions. The pump control program re-starts from the beginning and pumps down the instrument (as with instrument switch-on).

6.0 Alignment of EM 900

Chapter		Page
1	Alignment checks	6.1
	1.1 Check "1"	
	1.2 Check "2"	
	1.3 Check "3"	
2	Alignment of electron optics	6.3
3	Alignment of illumination system	6.3
4	Alignment of objective lens	6.4
5	Alignment of imaging system	6.5



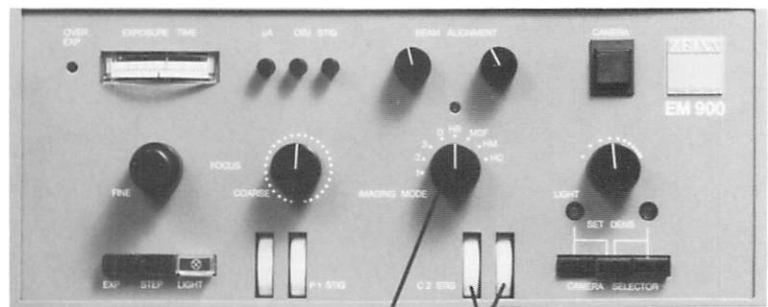
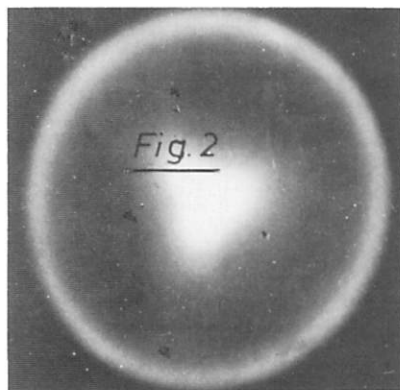
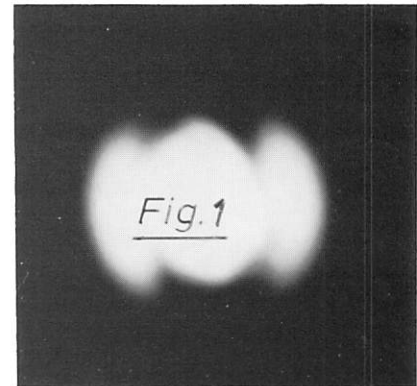
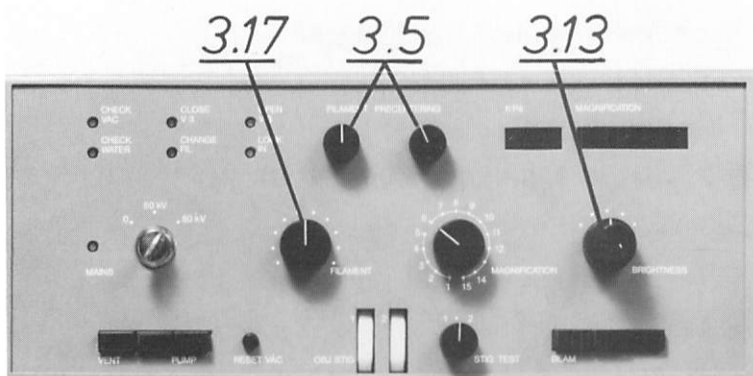
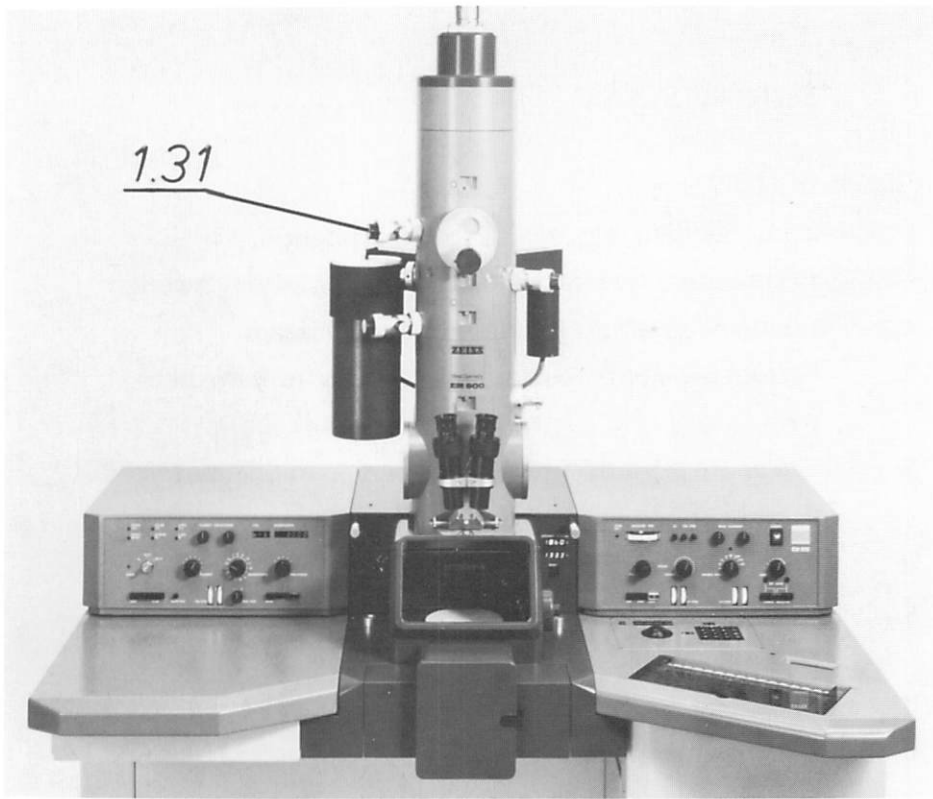
Chapter 1: Alignment checks

1.1 Check "1" (4.10)

Precentering of beam, e.g. after filament exchange.

NB: The fluorescent screen (1.94) must be completely swung down to prevent the shutter from blocking the beam.

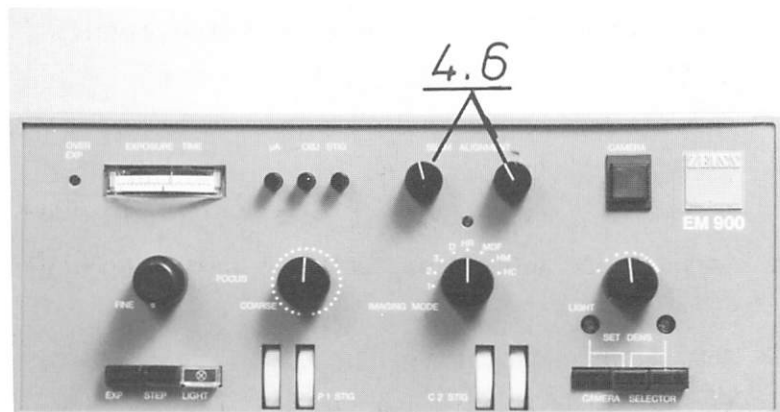
1. Retract the specimen and all apertures from the beam path.
2. Set beam alignment potentiometers to middle position: point of knobs (4.6) on dot marking.
3. Beam current switch (3.12) turned fully anticlockwise.
4. Filament heating knob (3.17) turned fully anticlockwise.
5. Switch-on of (3.22) and filament (3.23):
- 6.1 If no fluorescence is visible on the large fluorescent screen, proceed as described under 7. below.
Turn left filament centering potentiometer (3.5) fully anticlockwise. Turn right filament centering potentiometer (3.5) clockwise through its full range. If this does not bring the desired result, turn the left filament centering potentiometer clockwise through 45°, and the right one again clockwise through its full range. Continue until the result described under 6.1 is obtained.
7. Optimize the brightness on the fluorescent screen by alternately turning the filament centering potentiometers (3.5).



1.2 Check "2" (4.10)

Optimization of illumination

1. Switch to check "2" from the state described under 1.1/7.
2. Turn condenser (3.13) anticlockwise. The focused luminous spot lies in or around the center of the fluorescent screen. Please refer to Chapter 3, sections 3.1-3.3 if the spot is widely off center.
3. Underfocus condenser (3.13) slightly (turned almost fully anticlockwise). The caustic pattern becomes visible: correct the caustic star (Fig. 2) with the C2 stigmator (4.17).
4. Insert condenser aperture (1.31) and center it so that the luminous spot expands and shrinks concentrically to the luminous spot when over- and underfocusing the condenser (3.13).
5. Focus luminous spot to minimum diameter with condenser (3.13).
Increase the beam current until the underheated filament image becomes visible (Fig. 1). With FILAMENT PRECENTERING (3.5) symmetrize underheated filament image with reference to the luminous spot.
6. Increase filament heating until the shadow image is no longer visible (saturation).
NB: Overheating the filament (3.17) shortens its life. The filament heating should therefore be optimized for each beam current step.
7. Switch back to HR mode.



- 1.3 Check "3" (4.1) (relevant only for service technician)
Check "3" serves for polarity reversal of the objective lens to control its alignment. The objective lens is factory-aligned and should only be re-aligned with special tools by a service technician.

Chapter 2: Alignment of electron optics

The electron optics comprise the illuminating and imaging systems. Both can be aligned mechanically and electromagnetically. The electromagnetic base alignments are described in the chapter on the operation. The mechanical alignment is invariable. It is optimized by the service technician when the instrument is installed and should not be changed.

Alignment criteria: All diffraction points should lie within the photographic format. Alignment by shifting objective-lens/projector-lens.

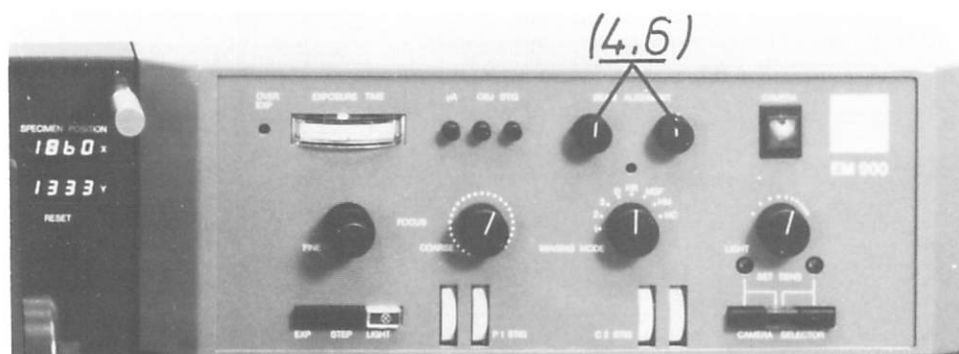
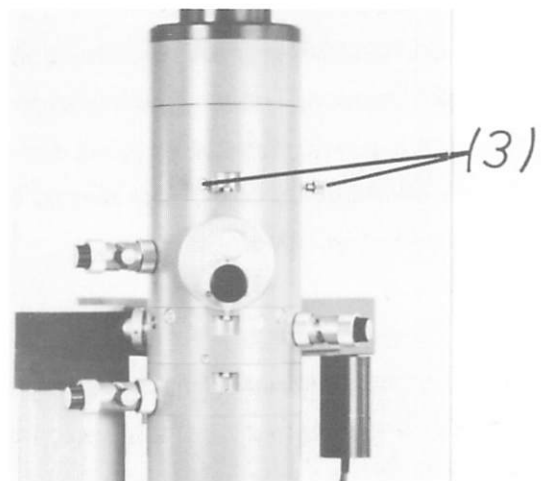
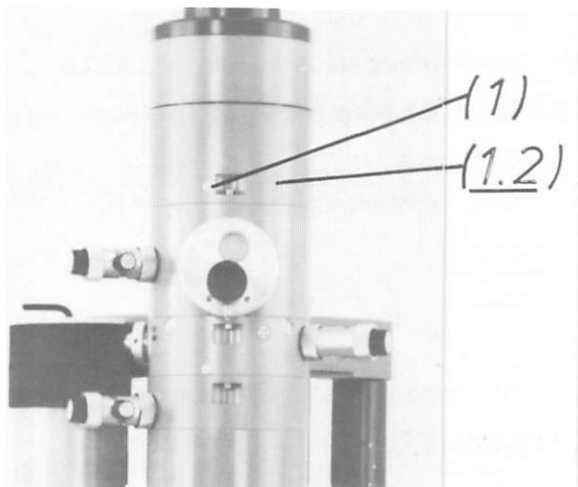
Chapter 3: Alignment of illumination system

The alignment of the illumination system to the imaging system can be made by the user. It is necessary only if the ranges of the beam alignment potentiometers (4.6) are not wide enough to permit centration of the focused electron beam.

Possible reasons:

- a) The filament is not exactly precentered to the Wehnelt aperture or shifted due to thermal changes.
- b) The anode borehole or the condenser cleaning tube is contaminated.

Check these points and eliminate defects, if any, before aligning the condenser.

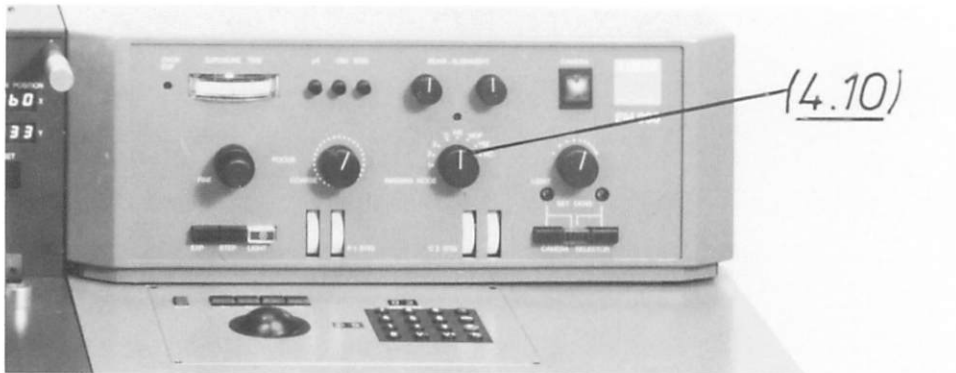
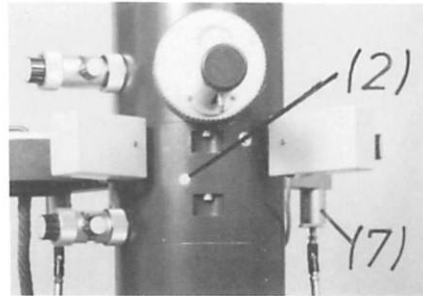
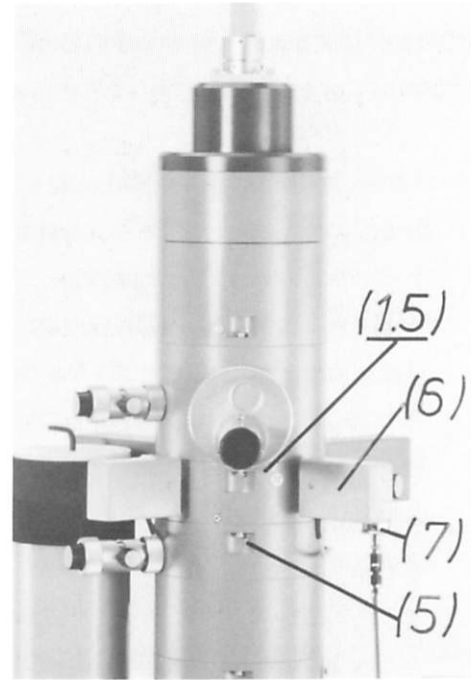
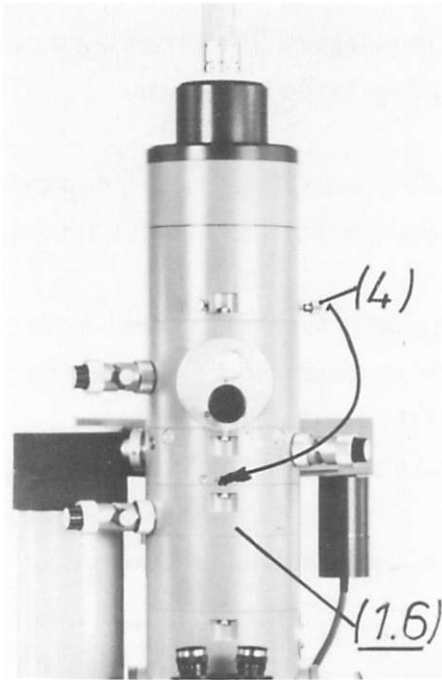


The double condenser in the anode housing (1.2) is factory-aligned. The lenses are mounted on a movable plate; the entire unit can be shifted $\pm 0.5\text{mm}$ relative to the beam axis.

- 3.1 Remove the three plastic overs (1) of the anode housing (1.2), and alternately screw in three screws (3), while observing the sweep directions of the luminous spots (3000x magnification on instrument).
- 3.2 Shift the condenser with two of the alignment screws towards the third, loosened screw. The alignment is correct if the beam alignment potentiometers (4.6) are in mid-range position and the luminous spot is centered on the fluorescent screen.
The luminous spot can now be moved beyond the edge of the fluorescent screen with the potentiometers (4.6).
- 3.3 Unscrew 3 alignment screws (3) from anode housing and put on covers (1).

Chapter 4: Alignment of the objective lens

The objective lens is factory-aligned, and should be re-aligned only with special tools by a service technician.



Chapter 5: Alignment of the imaging system

The projector-lens system (1.6) comprises three factory-aligned lenses; their alignment is invariable.

When three locking screws are loosened the objective lens with the entire upper column can be shifted relative to the fixed projector lens system to align objective-lens and projector-lens axes. Alignment is necessary if in mode D (4.10) the diffraction point sweeps considerably when changing between the magnification steps 1 through 5.

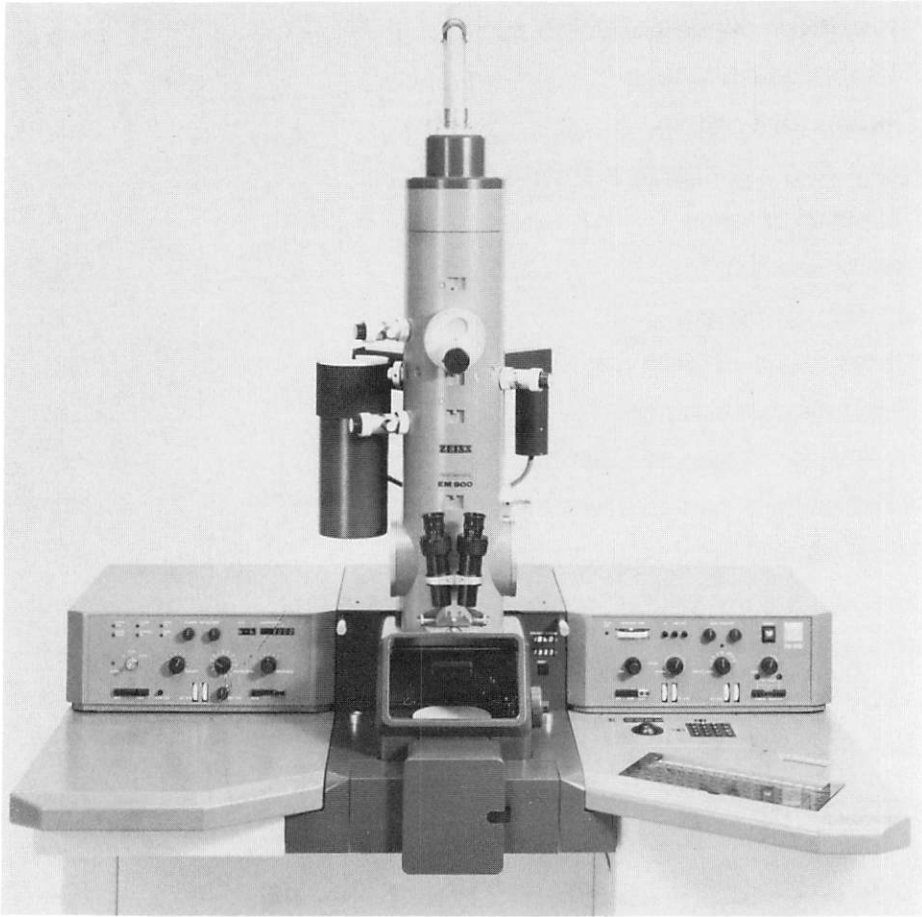
Remove Dewar vessel of anticontaminator.

Unscrew spindle (7), if any, of specimen stage drive, remove cap (6) of goniometer drive and three plastic covers (2).

1. Screw three alignment screws (4) all the way into objective-lens housing (1.5).
2. Loosen locking screws (5) (¼ turn) with short Allen screw.
3. Center diffraction point on fluorescent screen in step 5 with two of the alignment screws.
 Check alignment by changing between the 5 diffraction steps.
4. Alternately tighten the three locking screws (5) while observing the diffraction point (magnification step 5); it should lie within the photographic format.
5. Firmly tighten the three locking screws.
 NB: The stability of the image depends essentially on how firmly these screws are tightened.
6. Take out three alignment screws (4) and insert covers (2).
7. Mount cap, drive spindle and Dewar vessel.

7.0 Microprocessor-controlled vacuum system

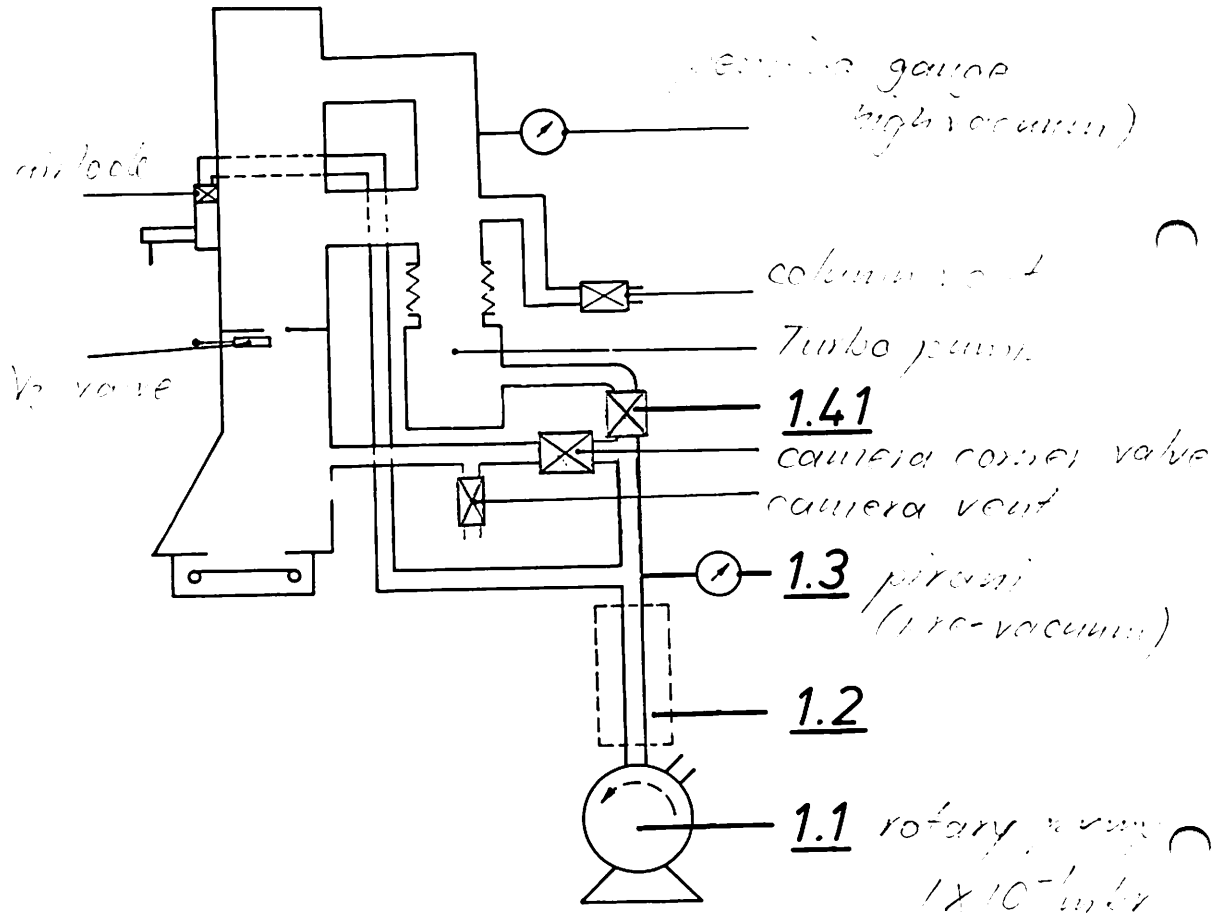
Chapter		Page
1	Vacuum system in general and in detail	7.1
	Description of pumps, valves, etc. (1.1-1.10)	7.2
2	Operating instructions	7.5
2.1	General information	7.5
2.2	Operating and display elements	7.5
3	Pumping process	7.6
3.1	System switch-on	7.6
3.2	System switch-off	7.7
3.3	Ventilation of column	7.8
3.4	Evacuation of column	7.8
3.5	Ventilation of camera chamber	7.8
3.6	Evacuation of camera chamber	7.9
3.7	Ventilation of both vacuum chambers	7.9
3.8	Evacuation of ventilated column and camera	7.10
3.9	Power failure	7.10
3.10	Lock-in/out	7.11
3.11	Baking program	7.11
4	Display of operating conditions	7.12
4.1	Category I	7.12
4.2	Category II	7.12
4.3	Category III	7.12
4.4	Codes of operating conditions (Table)	7.13
5	Service and maintenance	7.14



Chapter 1: Vacuum system of EM 900 in general and in detail

The vacuum system consists of a high-performance turbomolecular pump with a pumping capacity of 170l/s, and a two-stage rotary pump with a pumping capacity of 8m³/h.

A 200 μ m dia. differential aperture divides the vacuum chamber into two separate vacuum areas. The high-vacuum chamber including filament chamber, specimen chamber and electron optics is evacuated to 2×10^{-6} mbar by the turbomolecular pump. The rotary pump evacuates the lower part of the column, the viewing and the camera chambers, to 1×10^{-2} mbar. A microprocessor system provides for automatic and foolproof control of the entire vacuum system, and assures an oil-free high vacuum.



1.1 Rotary pump

The two-stage rotary pump with a pumping capacity of 8m³/h evacuates the ventilated column until the turbomolecular pump runs up, and then continues pumping on the pre-vacuum nozzle of the turbomolecular pump. The rotary pump evacuates at the same time the camera chamber and serves to pre-evacuate the specimen airlock.

1.2 Adsorption trap (accessory)

It provides an oil-free pre-vacuum for lock-in.

1.2.1 Anticontaminator (accessory)

It is run with liquid nitrogen, supports the turbomolecular pump, and minimizes the specimen contamination (not shown in the schematic drawing).

1.2.2 Oil mist filter (accessory)

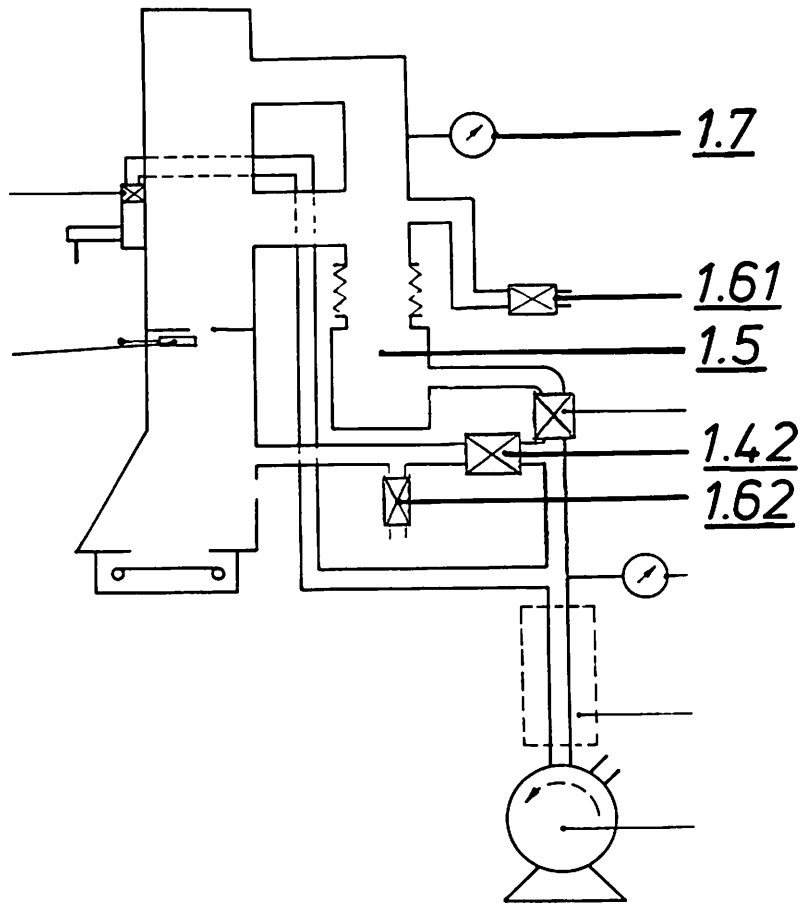
Because of its higher environmental consistence it should be attached instead of the central oil mist exhaust behind the rotary pump (the filter is not shown in the schematic drawing).

1.3 Pre-vacuum measuring tube (PIRANI system)

measures the pre-vacuum generated by the rotary pump.

1.4.1 Angle valve (turbomolecular pump)

Open in normal operating mode, shut for 30s during lock-in so that the rotary pump evacuates only the airlock.



1.4.2 Angle valve (camera)

Open in normal operating mode, shut for 30s during lock-in so that the rotary pump evacuates only the airlock.

1.5 Turbomolecular pump TPH 170

Pumping capacity 170l/s.

Operating principle: A turbine compresses the gas for pump-down from high- to pre-vacuum pressure.

Obtainable high vacuum in the column: 2×10^{-6} mbar.

Measurement of high vacuum by high-vacuum measuring tube (1.7).

Operating vacuum as from 2×10^{-4} mbar (go-ahead).

1.6.1 Ventilating valve (column)

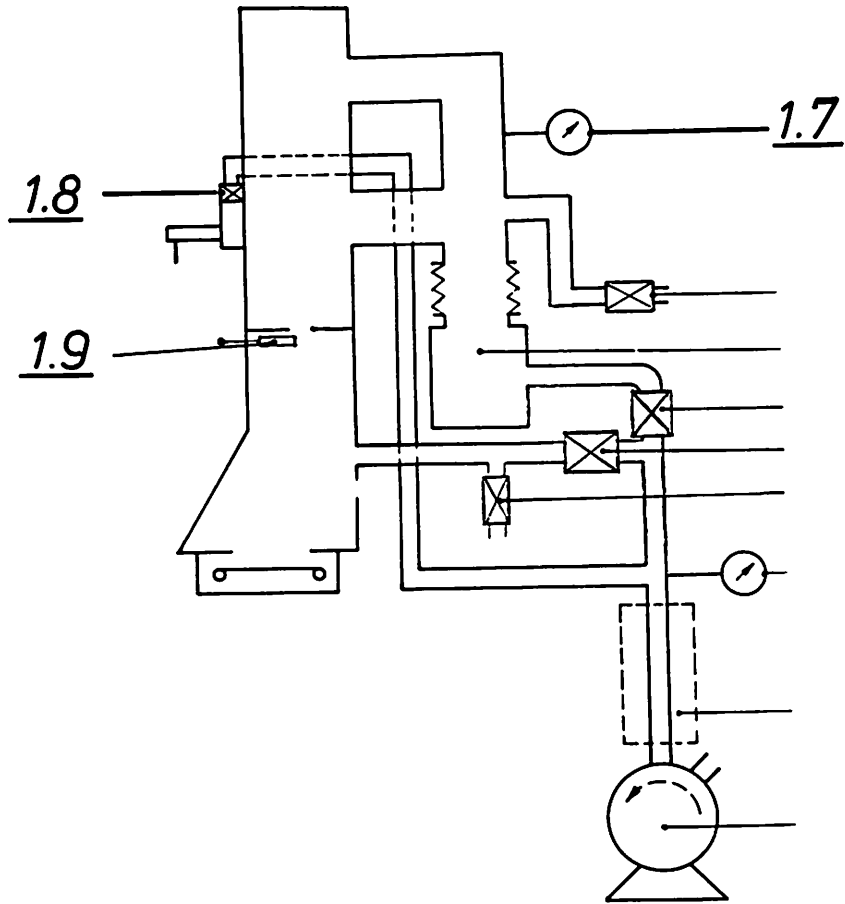
a) For flushing of the column when the instrument is switched off or in case of power failure. Flushing starts approx. ½ to 1min. after instrument switch-off, and takes approx. 15s. The instrument is flushed to approx. 100mbar.

b) To ventilate the instrument, e.g. when exchanging the filament.

1.6.2 Ventilating valve (camera)

to ventilate the camera, e.g. when exchanging the film in the inside-the-vacuum camera.

The ventilating valves for column and camera are connected with the desiccating cartridge (accessory) or with a cylinder with pre-dried nitrogen (accessory reducing valve). Ventilation and flushing with dried air or, better, dried nitrogen, shortens the pump-down time.



1.7 High-vacuum measuring tube (Penning system)

It is activated when approx. 50% of the speed of the turbomolecular pump and a pre-vacuum (better than 1×10^{-1}) are obtained. Digital pressure display (in decimal steps) from 5×10^{-3} to 1×10^{-7} mbar on the left panel. High-voltage go-ahead at 2×10^{-4} mbar.

1.8 Airlock valve

The rotary pump is switched to the airlock by pushing the key LOCK IN and manually turning the lock-in rod.

1.9 Manual isolation valve V3

When shut it separates the two vacuum areas for:

- a) separate ventilation of column
- b) separate ventilation of camera

The valve V3 must be opened before switch-on of the beam (required for high-voltage go-ahead).



3.14

3.15

3.25

3.6

Chapter 2: Operating instructions

The power switch on the power supply must be activated, and the power signal lamp ON.

2.1 General information

A differential aperture divides the vacuum chamber of the EM 900 into two separate areas (differential pump system). The upper area with filament and specimen chambers is evacuated by the turbomolecular pump, the lower area with viewing head and camera chamber by the two-stage rotary pump. The latter operates at the same time on the pre-vacuum nozzle of the turbomolecular pump.

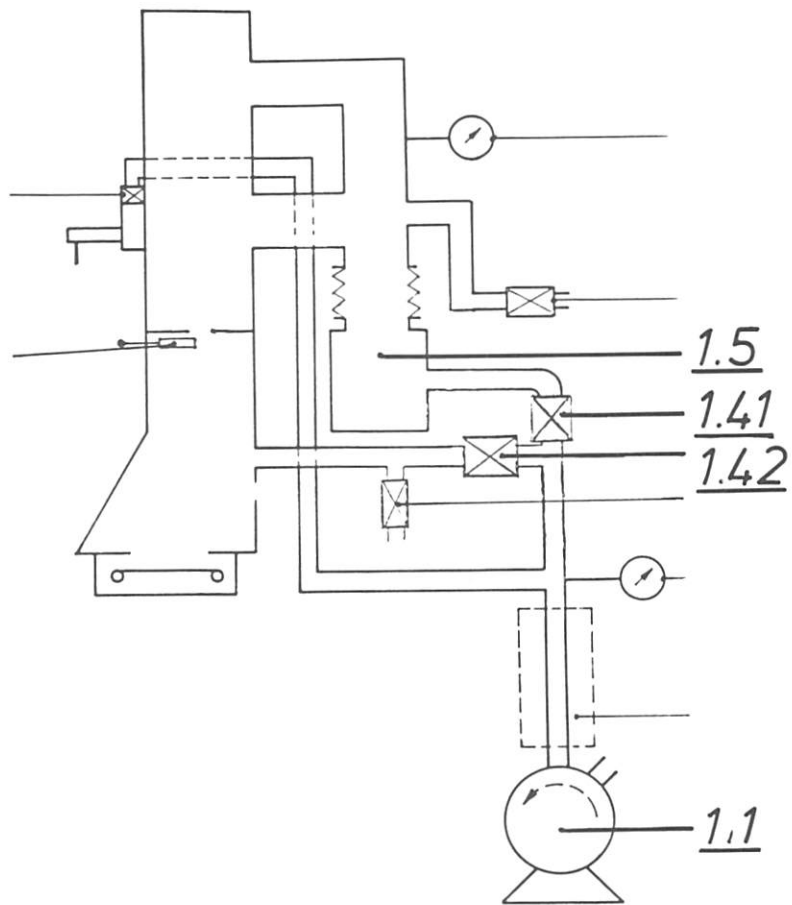
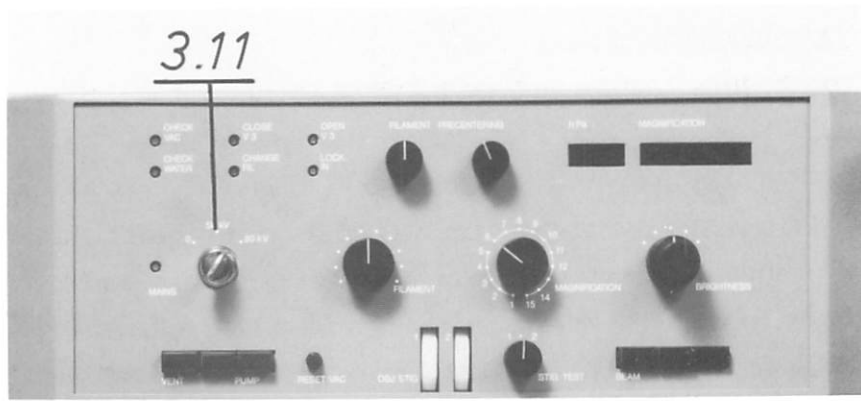
The pump system is microprocessor-controlled, which guarantees flexible operation; operating conditions are displayed for easy recognition.

2.2 Operating and display elements

The EM 900 vacuum system is controlled and operated from the control panel. The vacuum display (3.6) on the left panel also serves to display operating conditions.

The keys VENT COL (3.14) and VENT CAM (3.15) are not locked when held down.

When operating conditions are displayed (see Chapter 4) the control program can be reset with the key RESET VAC (3.25).



3. Pumping process

The entire pumping process of the EM 900 is microprocessor-controlled. The single pumping phases are described below.

3.1 System switch-on

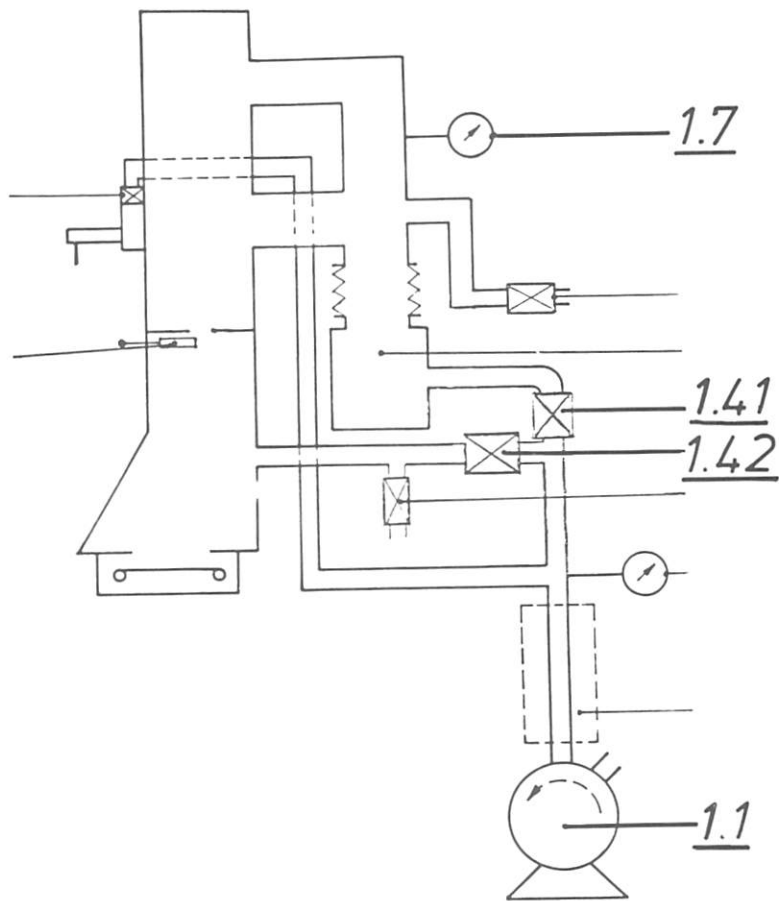
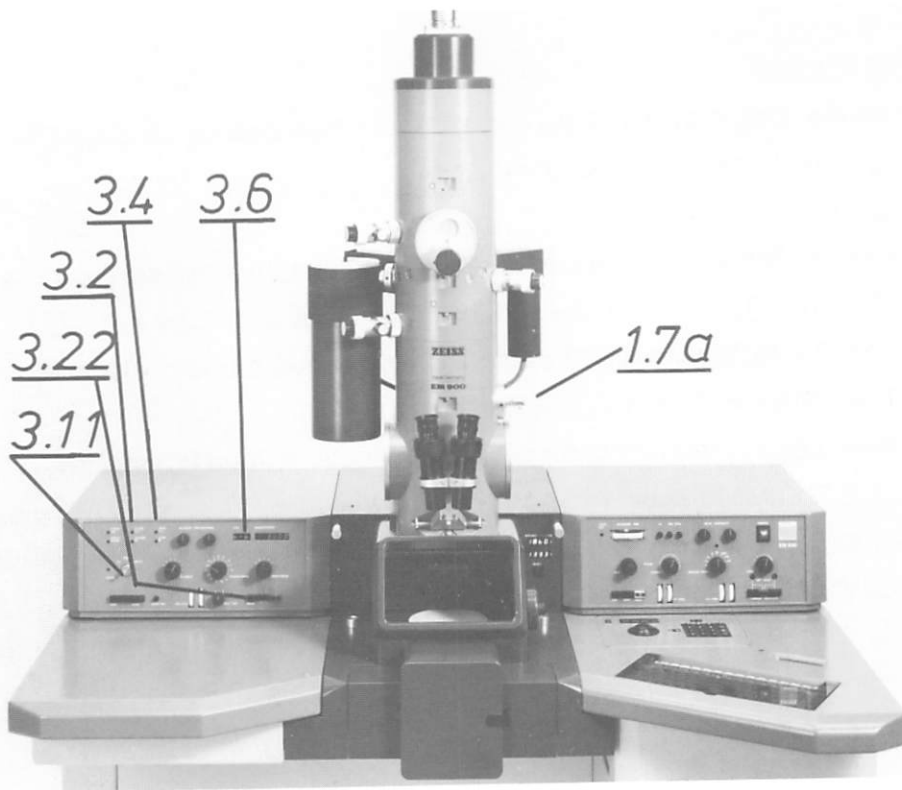
3.1.1 Turn the key switch (3.11) from 0 to 50/80kV: the pump control program starts.

3.1.2 The rotary pump (1.1) starts and evacuates the pre-vacuum tube to 1×10^{-1} mbar.

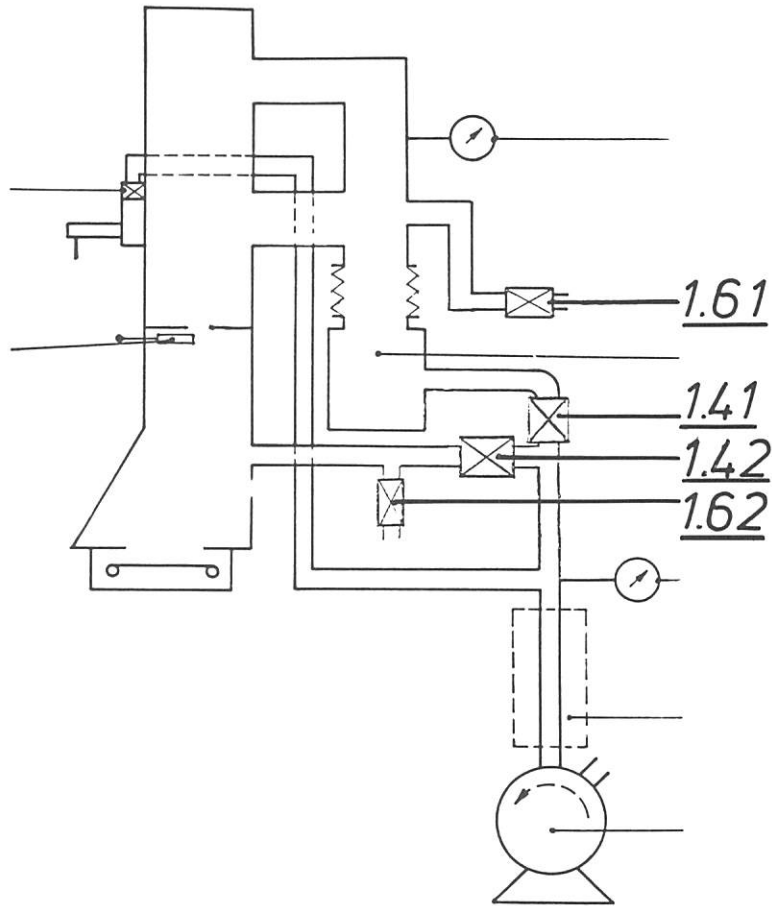
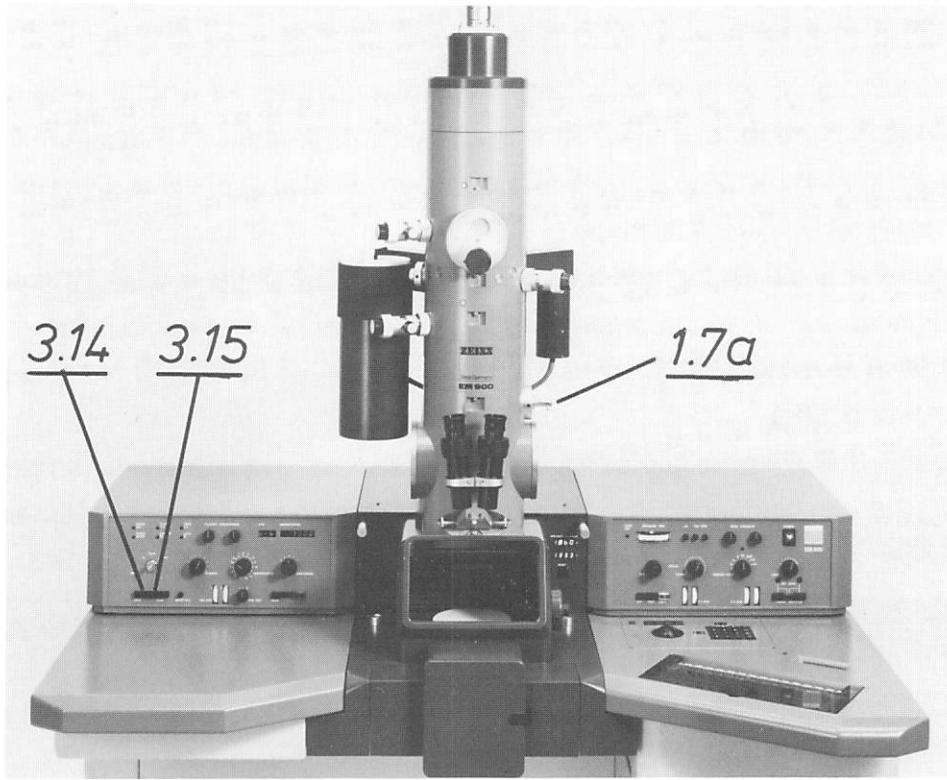
3.1.3 Angle valve (1.4.2) is opened, the camera chamber evacuated until a pressure of 1×10^{-1} mbar is obtained, and valve (1.4.2) closed.

3.1.4 Angle valve (1.4.1) is opened and the turbomolecular pump (1.5) started.

3.1.5 Valve (1.4.2) is opened again when the pre-vacuum has arrived at 1×10^{-1} mbar. The rotary pump (1.1) operates simultaneously on the exhaust nozzle of the turbomolecular pump and the camera chamber.



- 3.1.6 If the turbomolecular pump (1.1) arrives at approx. 50% of the nominal speed and the pre-vacuum pressure is better than 1×10^{-1} mbar, high-vacuum measurement (Penning measuring tube) (1.7) is activated. The vacuum display (3.6) lights. Display from 5×10^{-3} to 1×10^{-7} mbar in decimal steps.
- 3.1.7 Required conditions for high-voltage go-ahead (isolation valve V3 (1.7a) open):
- high-vacuum pressure below 2×10^{-4} mbar (measured by Penning system)
 - pre-vacuum pressure below 1×10^{-2} mbar (measured by PIRANI pre-vacuum measuring tube)
- 3.1.8 If these conditions are fulfilled, the lamp in OPEN V3 (3.4) lights, and the isolation valve V3 (1.7a) can be opened. If (1.7a) is open the lamp in the high-voltage go-ahead (3.22) is ON.
- 3.2 System switch-off
- 3.2.1 Turn the key switch (3.11) from 80/50kV to 0.
- 3.2.2 Required for switch-off: valve (1.7a) must be closed. If not, the lamp in CLOSE V3 (3.2) lights. The switch-off program continues if V3 is closed.
- 3.2.3 Angle valves (1.4.1) and (1.4.2) are closed. High-vacuum measurement, turbomolecular and rotary pumps are switched off.
- 3.2.4 After approx. 30s the ventilating valve is opened for approx. 15s for flushing of the column.



3.3 Ventilation of the column

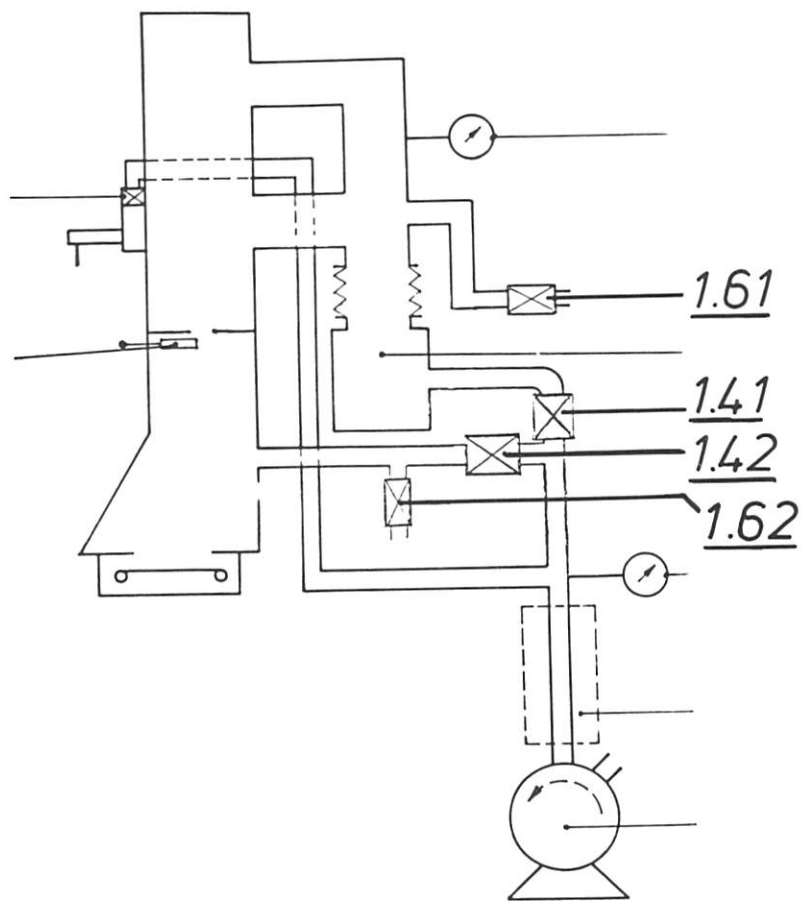
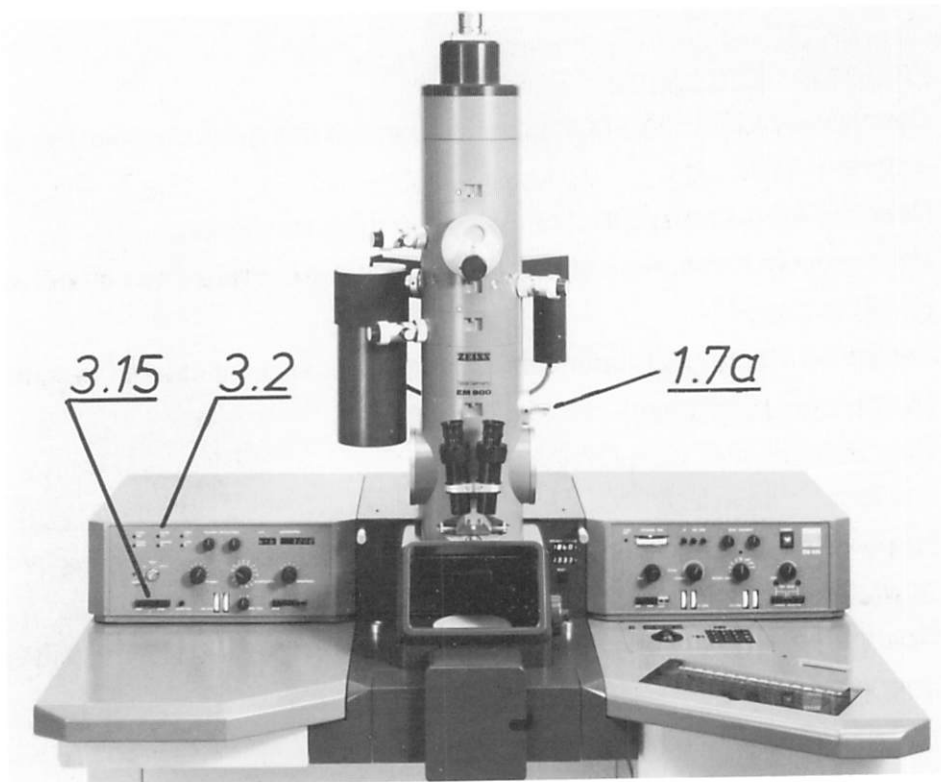
- 3.3.1 Operate key VENT COL (3.14); the lamp in this key goes on when the ventilation program starts.
- 3.3.2 Required for column ventilation: V3 (1.7a) must be closed.
- 3.3.3 High-vacuum measurement and turbomolecular pump are turned out and angle valve (1.4.1) is closed.
- 3.3.4 Ventilating valve (1.6.1) opens after approx. 30s and the column is ventilated.

3.4 Pump-down of column

- 3.4.1 Operate key VENT COL (3.14).
- 3.4.2 The lamp in key VENT COL (3.14) goes out and ventilating valve (1.6.1) is closed.
- 3.4.3 Angle valve (1.4.2) is closed and the pump program continues as under 3.1.4.

3.5 Ventilation of camera chamber

- 3.5.1 Operate key VENT CAM (3.15); the lamp in this key goes on when the ventilation program starts.
- 3.5.2 Required for camera ventilation: V3 (1.7a) must be closed.
- 3.5.3 Angle valve (1.4.2) is closed.
- 3.5.4 Ventilating valve (1.6.2) is opened and the camera chamber ventilated.



3.6 Pump-down of camera chamber

3.6.1 Operate key VENT CAM (3.15).

3.6.2 The lamp in VENT CAM (3.15) goes out and the ventilating valve (1.6.2) is closed.

3.6.3 Angle valve (1.4.1) is closed and angle valve (1.4.2) opened.

3.6.4 Angle valve (1.4.1) is re-opened when 1×10^{-1} mbar are obtained, and the pump program continues as under 3.1.6.

The pump-down time depends on the length of the film and the pre-drying time.

3.7 Ventilation of both vacuum chambers

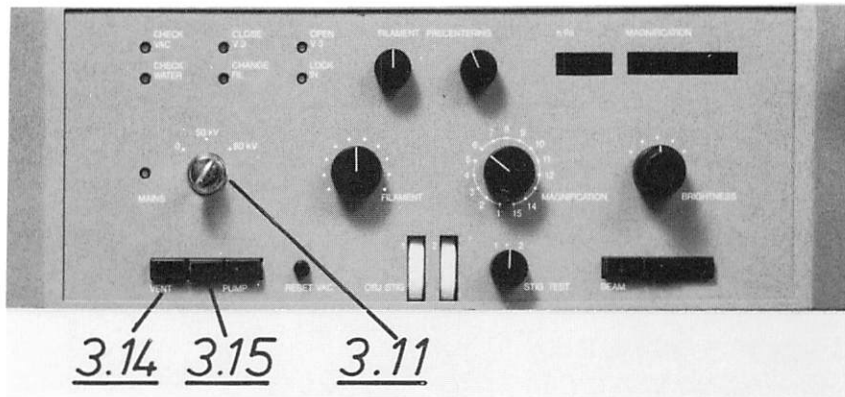
The two vacuum chambers can only be ventilated successively, but not at the same time.

a) During ventilation of the camera chamber, the column can only be ventilated when ventilating valve (1.6.2) has been opened.

b) During ventilation of the column, the camera chamber can only be ventilated when ventilating valve (1.6.1) has been opened.

Required for ventilation of both vacuum chambers: V3 (1.7a) must be closed.

NB: If V3 (1.7a) is opened during ventilation, the lamp in CLOSE V3 (3.2) flashes, but the pump program is not started.



3.8 Pump-down with ventilated column and camera

If both vacuum chambers are ventilated, the camera chamber must be pumped down first. If the key VENT COL (3.14) is operated first, the lamp in VENT CAM (3.15) flashes, which displays that the camera chamber must be evacuated first.

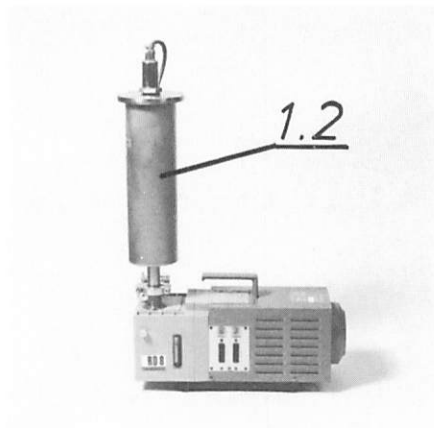
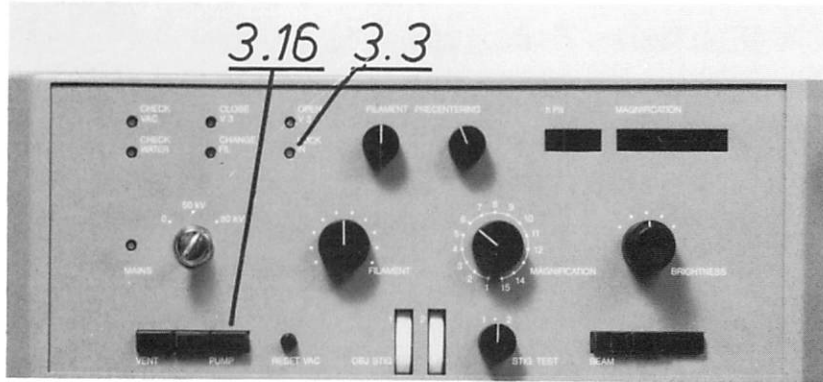
During evacuation of the camera chamber, the column can be pumped down only if the pre-vacuum pressure of 1×10^{-1} mbar is obtained in the camera chamber: the lamp in VENT COL (3.14) flashes. Flashing stops after 1 minute.

3.9 Power failure

Everything is switched off and all valves are closed in case of power failure. After 1 to 2s the system is flushed for approx. 1s.

The pump program starts from the very beginning when the power is switched on again (see 3.1).

The pump program starts automatically if the key switch (3.11) is in position 50kV or 80kV.

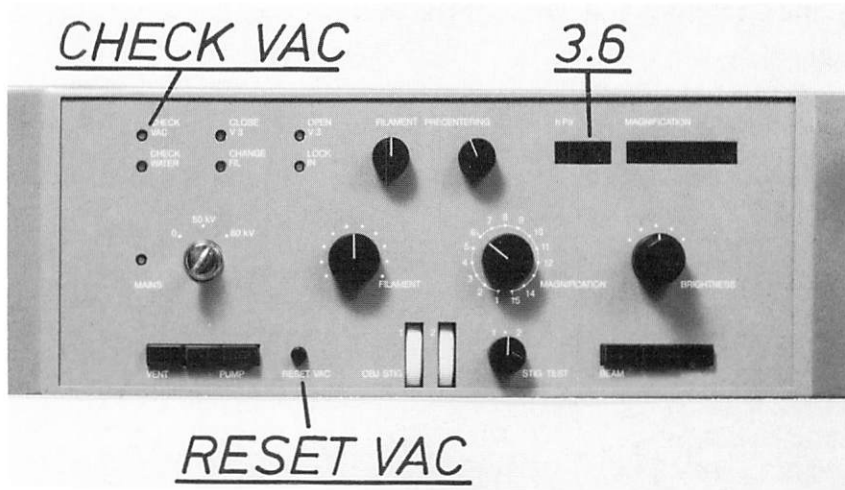


3.10 Lock-in/out

Possible only in normal mode (the requirements specified under 3.1.7 must be fulfilled). Pushing the key LOCK (3.16) closes both angle valves for 30s, and the lamp in LOCK IN (3.3) goes on. The lamp in LOCK IN (3.3) goes out during lock-in (lock-in rod in three o'clock position); it goes on if a pre-vacuum pressure of better than 1×10^{-1} mbar is obtained (lock-in time approx. 5s).

3.11 Baking program for adsorption trap (1.2) (accessory)

The baking program is integrated in the pump control. It is initialized during instrument switch-off (within 30s after switch-off) by pushing the key LOCK (3.16): the rotary pump runs up, the filament is switched on. The filament is switched off after 1½hrs, the rotary pump after 3hrs.



4. Display of operating conditions

The vacuum control system of the electron microscope displays the pressure and the operating conditions of the vacuum system. The latter are divided into the following categories:

4.1 Category 1

Only the lamp in CHECK VAC lights, which means that the operating vacuum (high vacuum pressure 2×10^{-4} mbar; pressure in the camera chamber 1×10^{-2} mbar) not obtained in the set time, or minor leaks or gassing exceeding the operating point in continuous operation. The vacuum system continues and gives high-voltage go-ahead when the operating vacuum is obtained again. Possible codes: 1-0, 2-0, 3-0, 4-0.

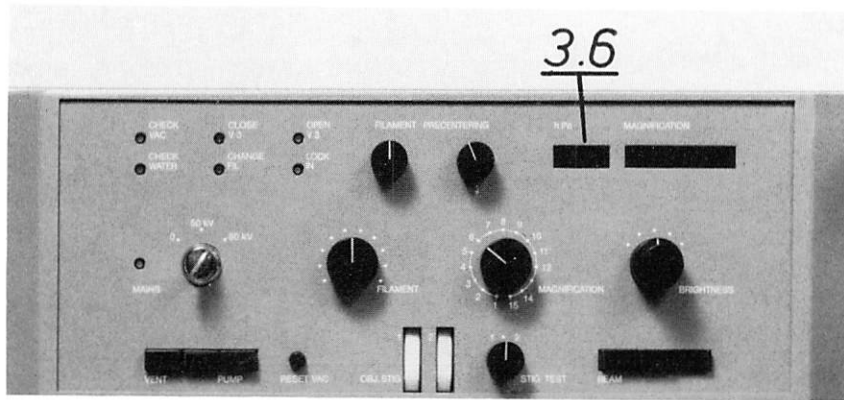
4.2 Category 2

The lamp in CHECK VAC lights. The instrument is switched off and a code number with 0 as final digit (e.g. 9-0) is displayed on (3.6), displaying major vacuum leaks or a non-functioning vacuum pump. Eliminate the faults. The system is re-started by pushing the key RESET VAC. Possible codes: 5-0, 6-0, 7-0, 8-0, 9-0.

4.3 Category 3

The lamp in CHECK VAC lights, the instrument is switched off, and the code 3-1 displayed instead of the vacuum. Please call a service technician. The instrument is re-started by pushing the key RESET VAC. Possible codes: 0-1, 3-1.

7.13



4.4 Codes of operating conditions

Category	(3.6) Code	Description of operating condition
I Minor vacuum leak	1-0	High-vacuum pressure 2×10^{-4} mbar not obtained within 20min. during pump-down.
	2-0	Pre-vacuum pressure 1×10^{-2} mbar not obtained within 20min. during pump-down.
	3-0	Pre-vacuum pressure exceeded in normal operation. Pre-vacuum less than 1×10^{-2} mbar. (Leak or excessive gassing with films in the camera.)
	4-0	High vacuum drops to below 2×10^{-4} mbar in normal mode (leak).
II Serious vacuum leak	5-0	Pre-vacuum pressure 1×10^{-1} mbar not obtained within 1min. during evacuation of the pre-vacuum distributor (leak or non-functioning rotary pump.)
	6-0	Pre-vacuum pressure 1×10^{-1} mbar not obtained within 10min. during evacuation of the camera chamber (leak).
	7-0	Pre-vacuum pressure 1×10^{-1} mbar not obtained within 10min. during evacuation of the column (leak).
	8-0	Turbomolecular pump does not arrive at 50% of the nominal speed within 4min. during pump-down.
	9-0	The pre-vacuum pressure drops to less than 1×10^{-1} mbar for more than 4min. in normal mode (lasting serious leak in normal mode.)
III Service technician	0-1	The speed of the turbomolecular pump drops in continuous operation, and 50% of the nominal speed are not obtained within 4min.
	3-1	Output voltage of the high-vacuum measuring tube below 0.1V. (Measuring line broken, measuring instrument defective or measuring tube contaminated.)

Chapter 5: Service and maintenance

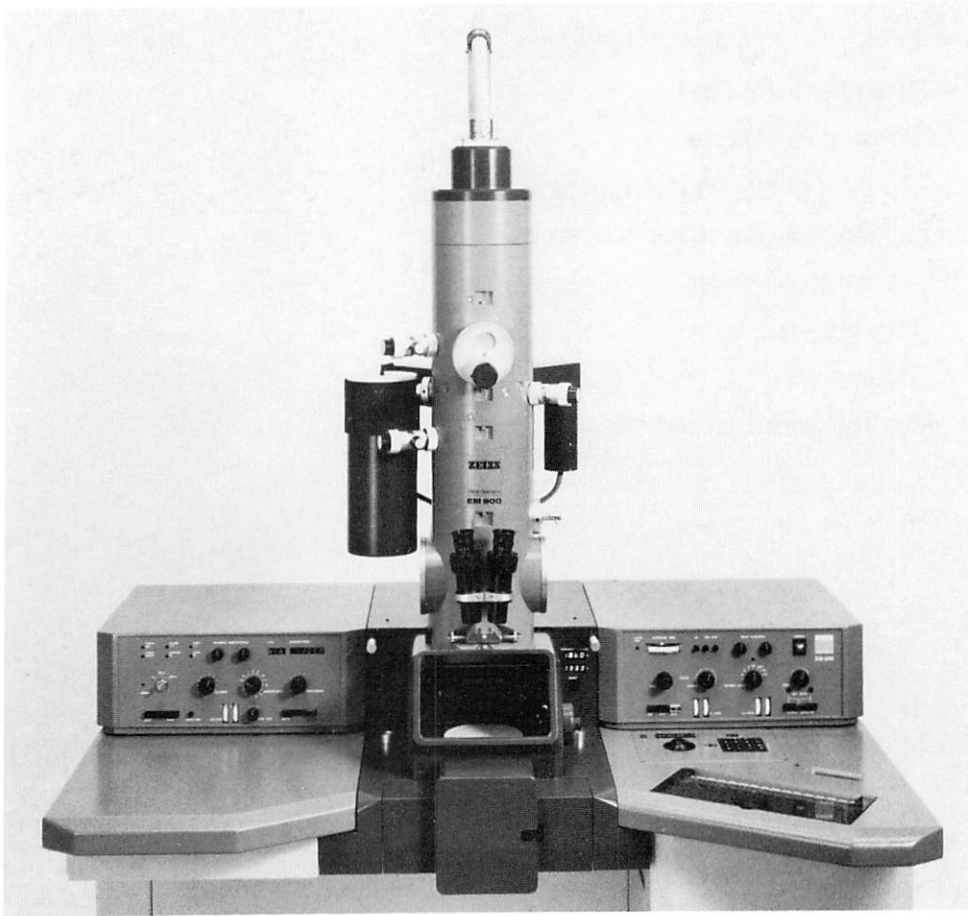
Service and maintenance of the turbomolecular pump should be carried out after 5000 operating hours and/or once a year by a service technician, preferably within the framework of a service contract.

The service technician should be called if the operation of the turbomolecular pump causes disturbing vibrations, or the sound of the pump changes and the vibrations increase considerably within short time.

For further information see the PFEIFFER operating manual.

8.0 Maintenance and service EM 900

Chapter		Page
1	General information	8.1
2	Filament exchange	8.2
3	Cleaning of column components	8.4
4	Exchange of fluorescent screens	8.8
5	Exchange of lamps	8.9
6	Failure of displays	8.10
7	Fuses	8.10
8	Maintenance and service of vacuum pumps	8.11

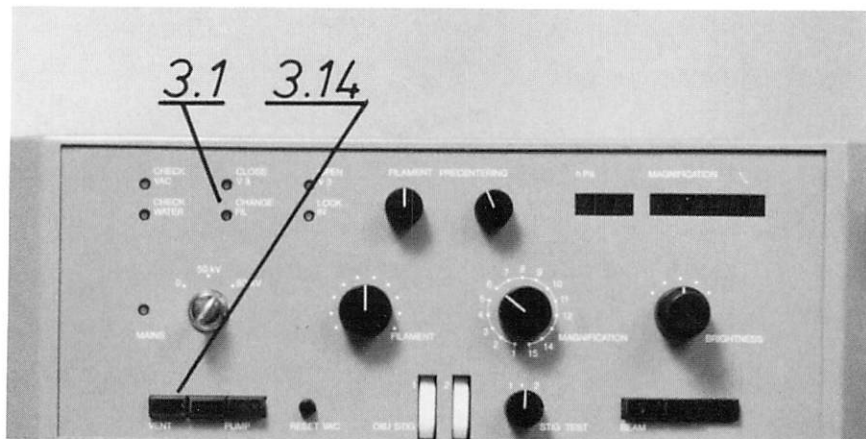
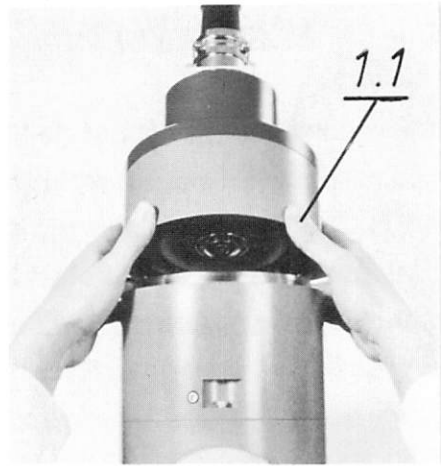
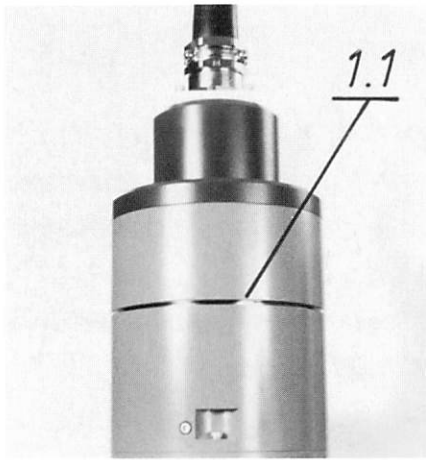


Chapter 1: General information

Regular maintenance and service of the EM 900 include the control of all functions (mechanical, electron-optical, electrical and electronic components including photography system, vacuum system with automatic control and cooling system), as well as cleaning and other maintenance measures intended to keep small troubles from becoming big problems.

Maintenance and service should be performed at regular intervals by a service technician under a service contract to be concluded upon expiration of the warranty period.

Some maintenance and service measures are described below, which the user himself may carry out, and instructions given for the exchange of expandable parts, provided such exchanges can be carried out by means of simple controls and auxiliary means.



Chapter 2: Filament exchange

The signal lamp CHANGE FIL (3.1) lights if the filament is burnt through.

Important for filament exchange: All exchange parts must be meticulously clean! Contamination causes high-voltage instability. A clean, centered filament holder and an anode should be kept in store to assure the shortest possible downtime.

Spare Wehnelt cylinder with centering screws

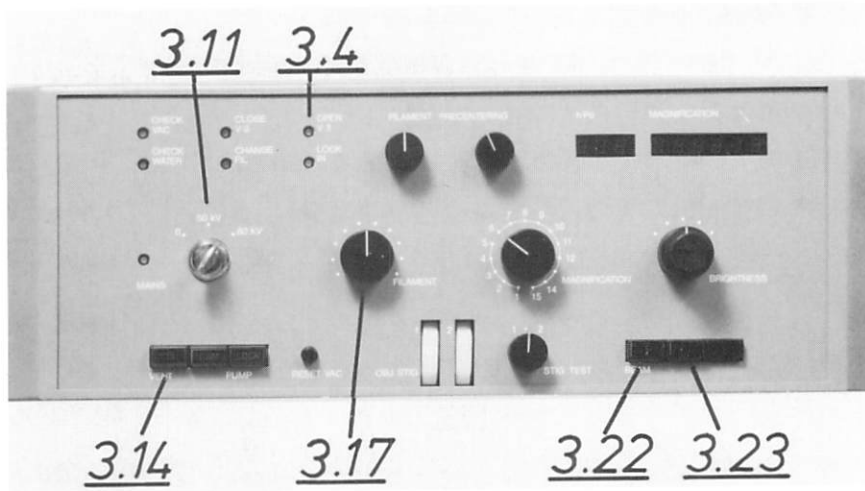
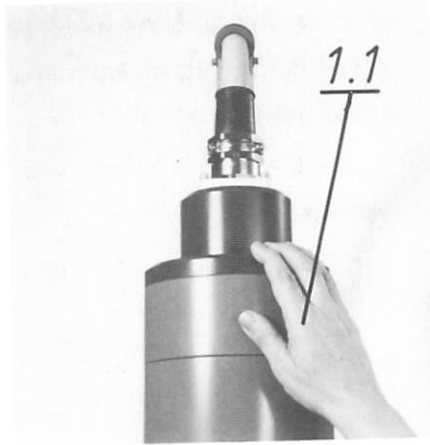
Cat.No. 34 56 45

Spare anode in container

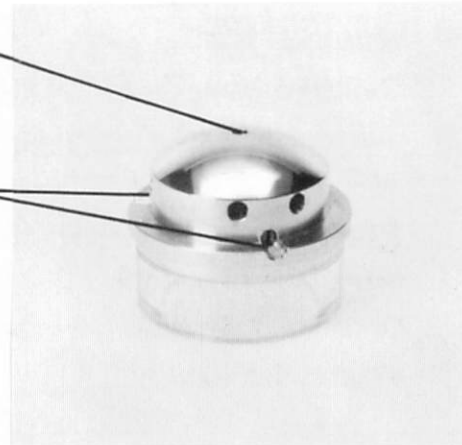
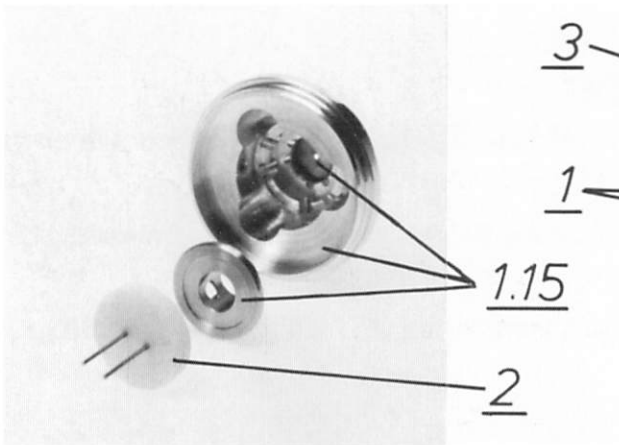
Cat.No. 34 09 65

Exchange of filament and anode

- 2.1 Push key VENT COL (3.14):
Cathode head (1.1) opens after automatic ventilation.
- 2.2 Swing back cathode head (1.1).
- 2.3 Unscrew securing ring (1.17) of Wehnelt cylinder: hold it with a clean glove and turn it anticlockwise.
- 2.4 Pull down filament holder (1.15) (Wehnelt cylinder) out of plug contact.
- 2.5 Plug in cleaned, exactly pre-aligned spare filament holder, put on securing ring (1.17) and tighten it lightly.



- 2.6 Check anode for cleanliness. With each filament exchange it should be replaced by a clean one.
- 2.7 Blow off dust particles or fluff on Wehnelt cylinder, anode and O-ring seal.
- 2.8 Swing down cathode head (1.1) and hold it until pumpdown starts. The column is evacuated: Push key VENT COL (3.14). High-voltage go-ahead at 2×10^{-4} mbar. The light in OPEN V3 (3.4) is on. *Open V3.*
Switch-on after filament exchange
Important for the elimination of sparkovers!
- 2.9 Set high voltage to 50kV with key switch (3.11). **Do not push** high-voltage go-ahead key (3.22)!
- 2.10 Turn filament heating potentiometer (3.17) fully anticlockwise.
- 2.11 Switch on high voltage (3.22) only when a high vacuum of better than 2×10^{-5} mbar is obtained.
- 2.12 Switch on filament with key (3.23).
- 2.13 Turn potentiometer (3.17) stepwise to medium position, and let deposits on the filament evaporate.
- 2.14 If the electron beam is not visible on the fluorescent screen, precenter the beam (Section 6, Chapter 1).
- 2.15 Switch to 80kV and make base alignment when the high voltage is stabilized (after approx. 5 to 10min.).



Chapter 3: Cleaning of column components

3.1 Cleaning the high-voltage electrodes

Wehnelt cylinder (1.15) and securing ring (1.17) should be cleaned every time the filament is exchanged, to assure proper functioning of the electron gun. For the disassembly see the preceding chapter about filament exchange.

Cleaning procedure: Remove heavy contamination such as black or brown-yellow deposits with metal polish and a soft, clean cloth or Q-tip. Remove metal polish residues first with acetone (toluene) and then wash the entire electrode surface thoroughly with alcohol. Heavily contaminated Wehnelt apertures may be polished with polishing paper (grain 800), and then cleaned in an ultrasonic bath. The polished electrode surface and especially the borehole of the Wehnelt cylinder should be absolutely free from dust particles and residues.

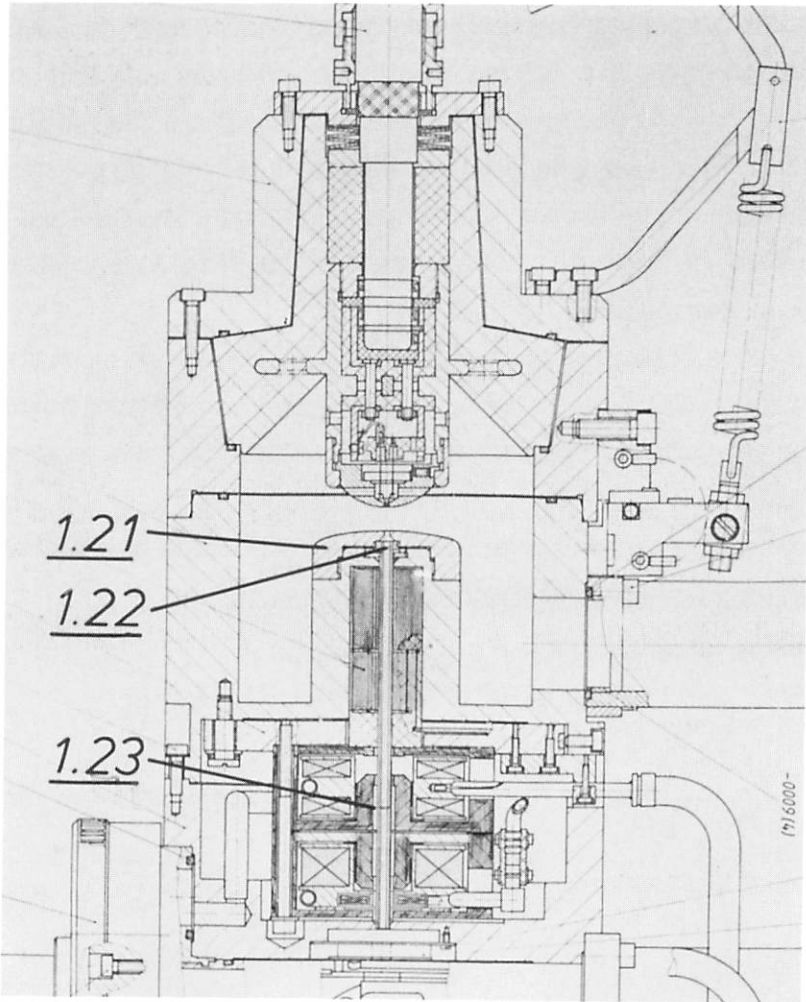
Preparation of filament holder: Loosen three locking and centering screws (1) so far that the filament (2) can be taken out. Thoroughly clean filament holder (1.15), as well as inside and outside of Wehnelt aperture and insert (remove evaporation deposits on the filament).

Insert new filament and align tip (3) visually to the borehole with three screws (1).

3.2 Cleaning the anode and the condenser cleaning tube

3.2.1 Cleaning the anode (1.21)

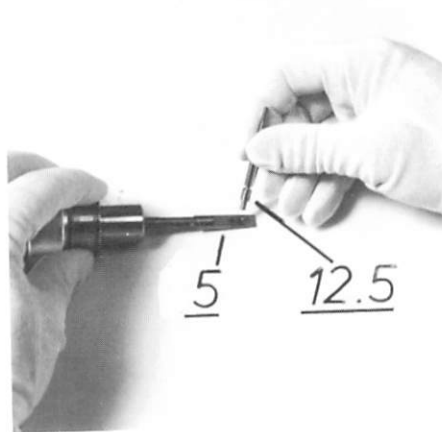
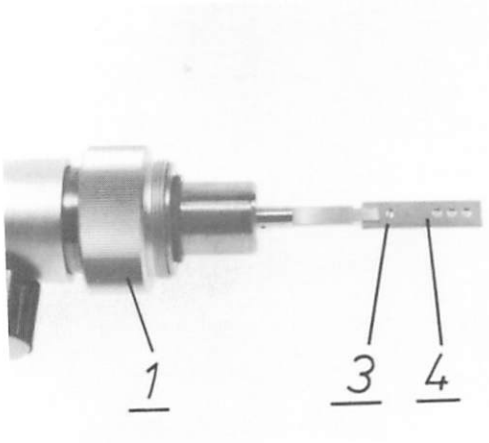
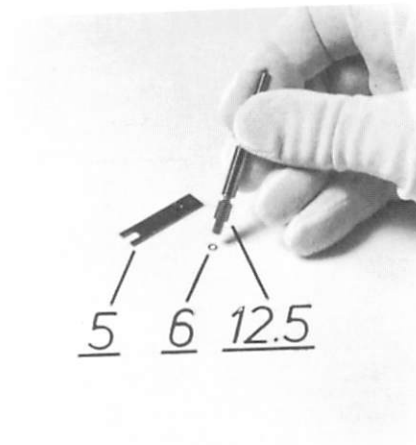
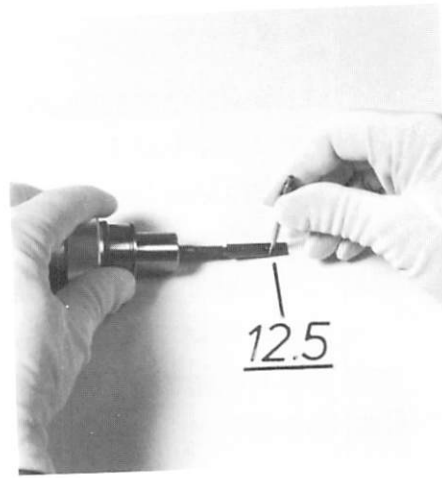
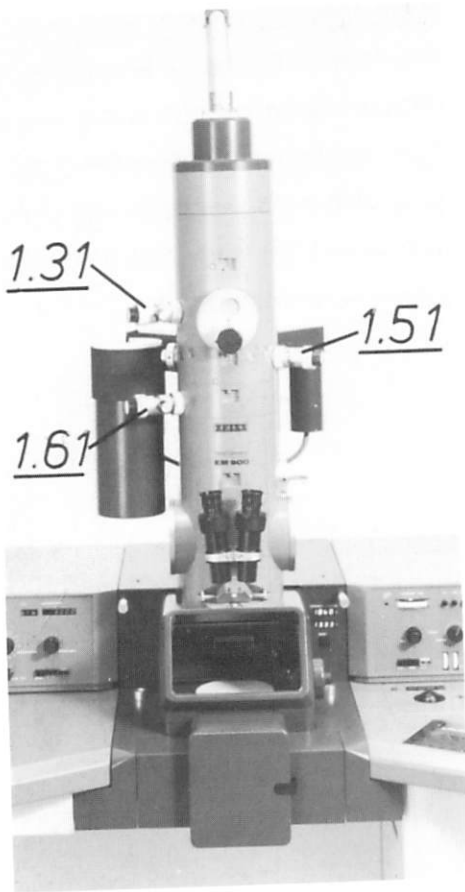
Unscrew the anode and clean as described in para. 3.1.



3.2.2 Condenser cleaning tube and built-in condenser aperture

Cleaning is necessary if with minimum illuminated area the beam sweeps slowly and/or jumps. Beam instability may be due to charging of contamination layers inside the condenser cleaning tube. Unscrew anode (1.21), pull out cleaning tube (1.22) on its collar and take it apart. Press C1 aperture (1.23) with a wooden stick out of the shorter tube. Clean inside of tubes and condenser aperture (1.23) with Q-tip as described in para. 3.1. The complete condenser cleaning tube is exchangeable.

Cat.No. 34 56 44.



3.4 Exchange of (adjustable) condenser, objective lens, and selector apertures

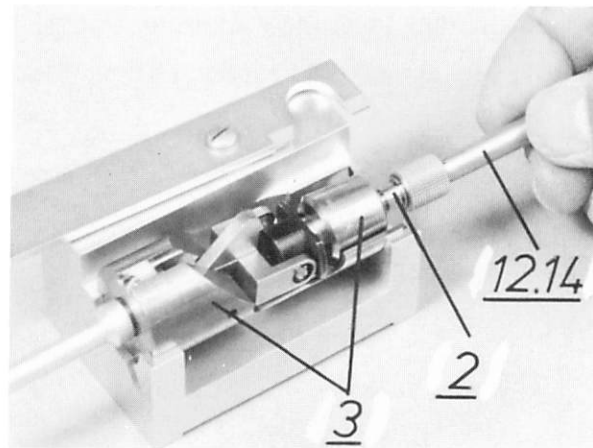
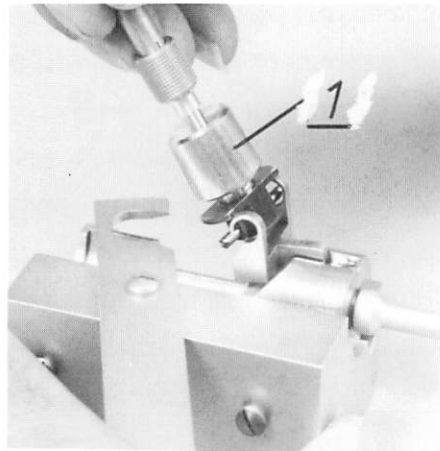
3.4.1 Condenser and selector apertures

Exchange is necessary if the apertures are contaminated: e.g. the rim of the selector aperture is contaminated, the beam displaced when the condenser aperture is inserted, or the condenser astigmatism changes with the change between apertures. For an exchange ventilate the column, unscrew securing ring (1) and take out aperture drive (1.31) or (1.61). Either place aperture holder (4) on a clean support, or (better) loosen screw (3) and remove aperture holder. Clean aperture holder as described in para. 3.1. Place clean aperture holder with conical hole (5) face down on a clean support. Insert clean aperture with conical borehole face up. Put on conical securing ring (6) with chamfer down. Press key (12.5) lightly together, catch securing ring (6) and release it. Press securing ring on aperture and retract key. Mount holder with aperture on aperture drive (screw (3)), insert aperture drive in column and secure with securing ring.

3.4.2 Thin-film apertures

Exchange is necessary in case of strong base astigmatism of the aperture that is measurable with a test method described in Section 5. Clear deviations from the base values determined without contrast aperture at 80kV or 50kV indicate poorly centered or contaminated contrast apertures.

Contrast aperture drive (1.51): For an exchange proceed as described under 3.4.1. The aperture cannot be cleaned. Insert new apertures in desired order in clean aperture holder with the copper ring face up. Proceed as described under 3.4.1.

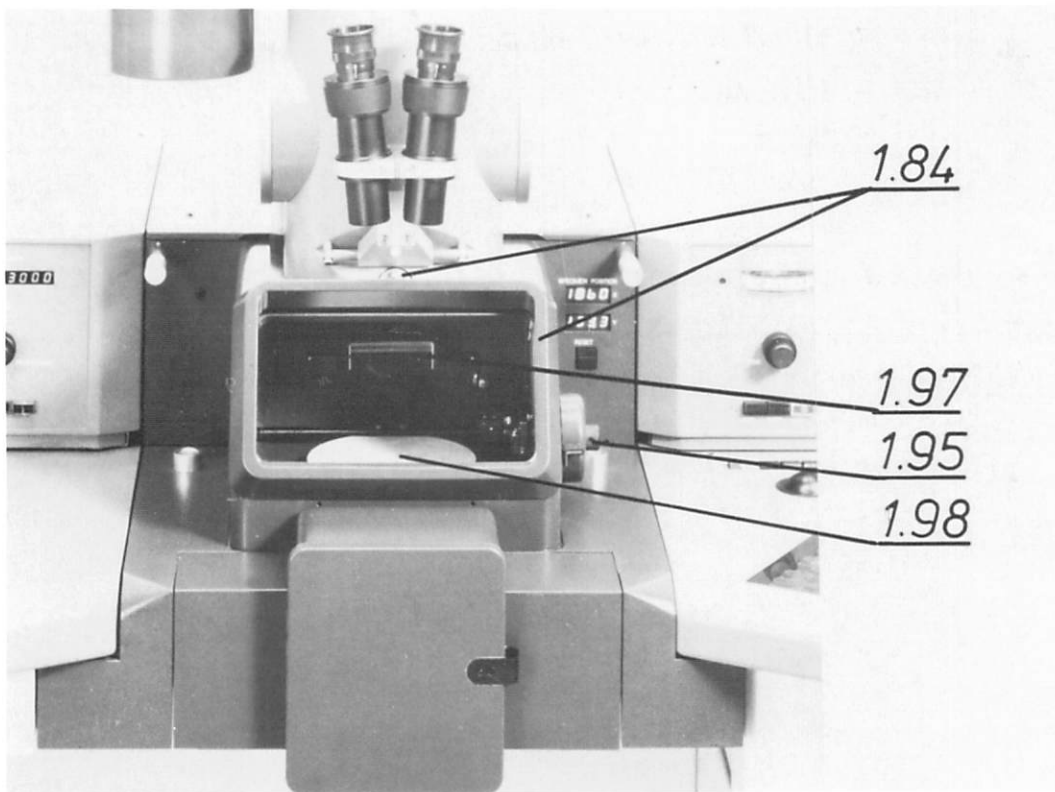
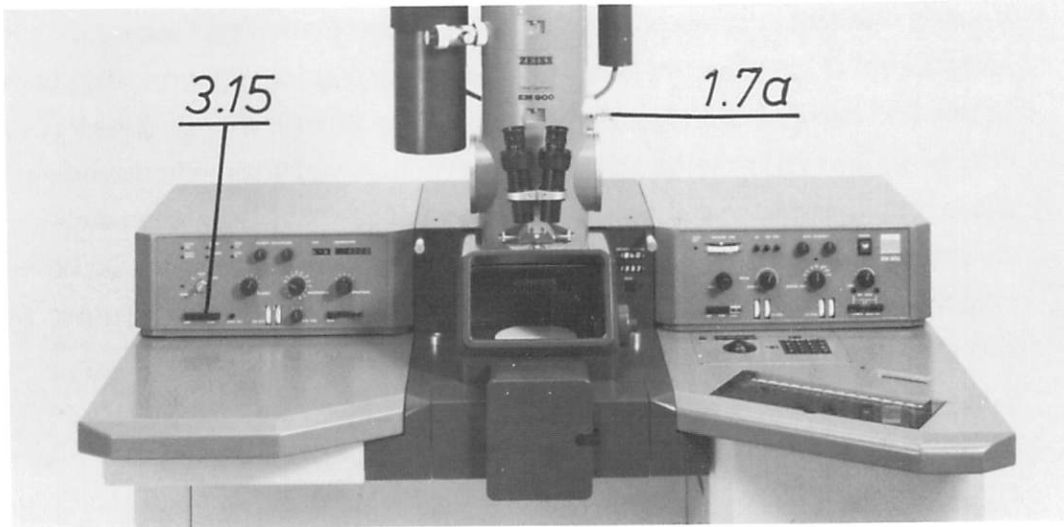


3.5 Cleaning the standard specimen cartridge for HR and HC modes

It needs cleaning in cases of charging of the image (periodical flashing) or sudden, high astigmatism of the objective lens. Place slide with cartridge (3) on specimen changing device and take out cartridge. Remove screw cap (2) with wrench (12.14). Clean outer conical surface (1) of the cartridge only with cotton wad soaked in acetone and alcohol. Clean and/or rinse thoroughly with solvent inner cartridge bore with specimen contact surface and screw cap (2), especially the specimen contact surface. Do not use metal polish! Do not touch the cartridge for insertion (use tissue paper or gloves). For cleaning of the goniometer cartridge see the operating instructions G 34-606.

3.6 Cleaning the cartridge slide

The slide or its bore must be cleaned if the beam is displaced during lock-in.



Chapter 4: Exchange of fluorescent screens

When exchanging both screens always exchange the small one first. Do not touch the fluorescent layer to prevent it from being damaged.

4.1 Small fluorescent screen (1.97)

4.1.1 Close V3 (1.7a) and ventilate camera chamber (3.15).

4.1.2 Remove window (1.84) after loosening M4 Allen screw. Caution: Do not touch conductive film on inner side of window. Wipe off contamination with a smooth cloth and alcohol.

4.1.3 Raise small fluorescent screen (1.97) approx. 30mm with rotary knob (1.95).

4.1.4 Hold carrier rod and with the other hand move fluorescent screen on the rod to the left until the binding strength slackens. Pull fluorescent screen (1.97) upwards from the rod.

4.1.5 Put spare fluorescent screen from above on carrier rod, and slide it against the stop pin from the outer left.

4.1.6 Control the fitting of the fluorescent screen on the carrier rod.

4.1.7 Put on the window, secure with screw (do not tighten!) and evacuate instrument.
Small fluorescent screen in container: Cat.No. 34 09 62 0000

4.2 Large fluorescent screen (1.98)

4.2.1 as described in para. 4.1.1

4.2.2 as described in para. 4.1.2

4.2.3 Swing up small fluorescent screen as far as upper limit stop.

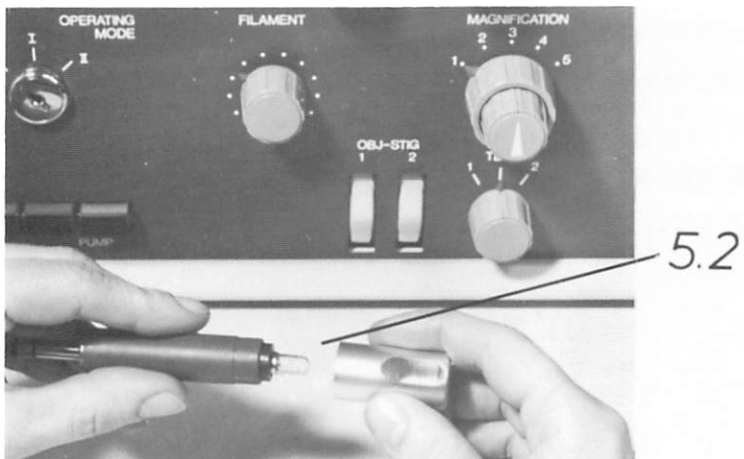
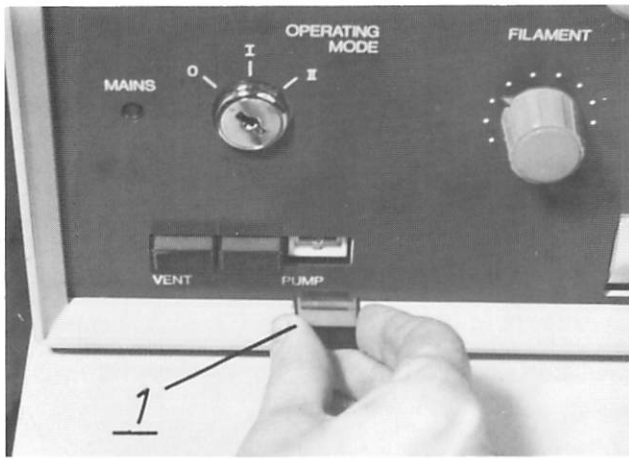
4.2.4 Loosen and remove both Allen screws in the fluorescent screen shaft.

4.2.5 Pull large fluorescent screen (1.98) forward.

4.2.6 Place spare screen on support ring and slide it back until both threaded boreholes lie below the corresponding shaft bores. NB: Do not move the fluorescent screen under the shaft to prevent the fluorescent layer from being damaged!

4.2.7 Plug two M4 Allen screws into shaft (do not let them drop!) and screw on the large fluorescent screen.

4.2.8 Put on window, secure with screw, and evacuate instrument.
Large fluorescent screen in container: Cat.No. 34 09 61 0000.



Chapter 5: Exchange of lamps

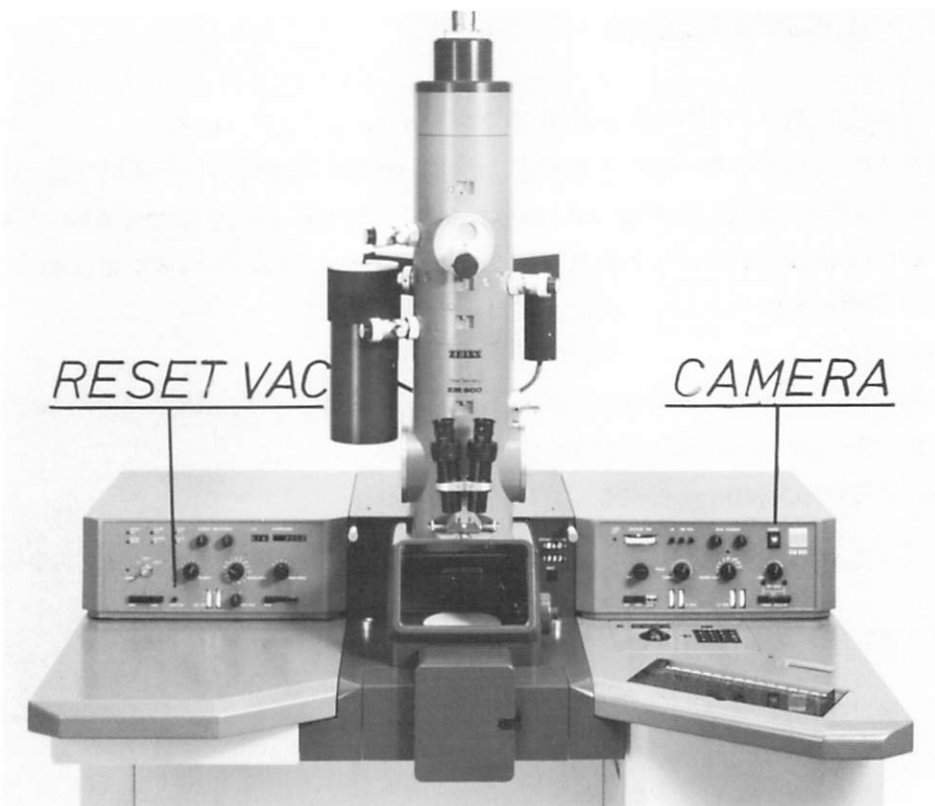
5.1 Lamps in keys (small 24V 20mA lamp)

They must be exchanged if the light in any of the keys fails. Pull off cap of key (1) (or use a screwdriver to lift it). Pull out lamp with tool (12.6). Insert spare lamp with properly oriented contact tip. Push the key; the lamp must light. Put on cap and press it down until it snaps in.

5.2 Desk lamp

If the lamp fails, pull off metal sleeve, take out lamp (bayonet mount) and insert new lamp. Switch on desk lamp and put on metal sleeve.

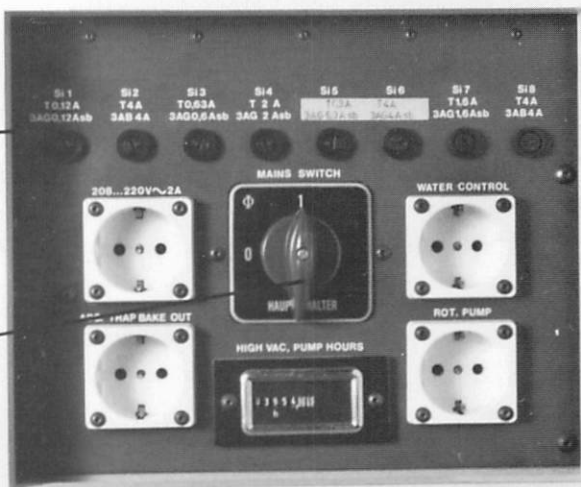
Set of filament lamps: Cat.No. 34 09 60 0000.



7.1

1-8

6.2



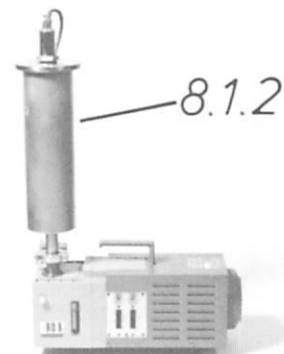
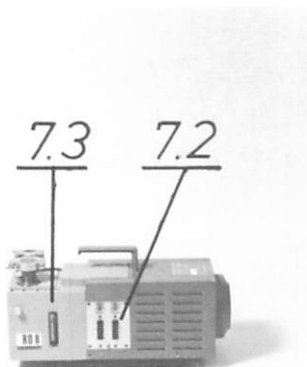
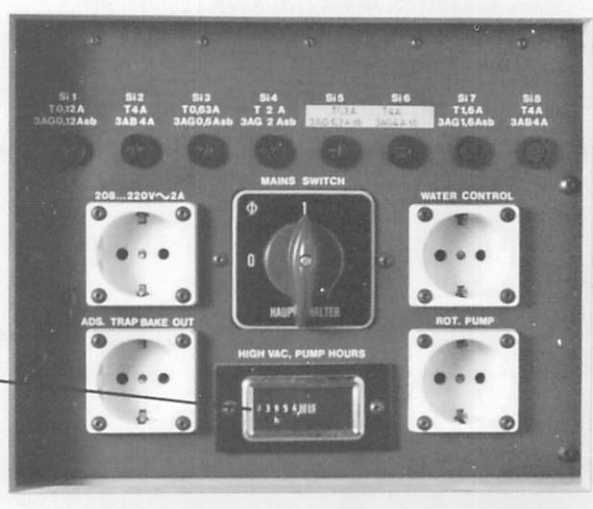
Chapter 6: Failure of displays

- 6.1 The power switch (6.2) on the back of the EM 900 also serves as reset switch, e.g. in case of irregularities of displays, vacuum pumps and sheet-film camera. For resetting turn power switch (6.2) to position 0 and after approx. 1 minute back to position 1. The sheet-film camera is switched off separately with CAMERA on the right control panel. Reset of the vacuum control is started by pushing the key RESET VAC.

Chapter 7: Fuses

- 7.1 If any of the electrical assemblies in the table below fails, switch off instrument with (6.2) and exchange the corresponding fuse.

Fuse 1	0.125A SB	Time control of vacuum system (transformer 1)
Fuse 2	4A SB	Rotary pump, pump control with turbomolecular pump
Fuse 3	0.63A SB	Switching of relays of angle valves (transformer 3)
Fuse 4	2A SB	Power supply of lenses and photography system
Fuse 5	6.3A SB	High voltage
Fuse 6	4A SB	Filament heating
Fuse 7	1.6A SB	Socket 4 water control
Fuse 8	4A SB	Sockets 1 and 2 (additional sockets)



Chapter 8: Service and maintenance of vacuum pumps**8.1 Oil exchange of rotary pump**

First oil exchange after 100 operating hours before the instrument leaves the factory.

The oil must also be exchanged if it is strongly discolored (window (7.3)) or at least after 2000 operating hours, indicated on operating hour counter (6.3) on the back of the EM 900.

8.1.1 Switch off instrument by turning key switch (3.11) to position 0.

8.1.2 Disconnect adsorption trap from exhaust flange (NW 25 FK) of pump and provide it with blind flanges on both sides to prevent the agent from becoming humid.

8.1.3 Provide exhaust flange with blind flange after removal of metal sieve and clean it by rinsing in solvent (e.g. acetone). Plug line plug of pump in either of the left CEE sockets (or CEE wall socket): the pump runs.

8.1.4 Proceed according to the supplied operating manual of the manufacturer.

8.1.5 Let pump run approx. 25 minutes with gas ballast after oil change: set toggle switch (7.2) of pump to gas ballast.

8.1.6 Connect adsorption trap (filled with new or regenerated agent) to pump, if any.

8.1.7 Plug power switch of pump into CEE socket ROTARY PUMP.

8.1.8 Set key switch (3.11) to 50kV.

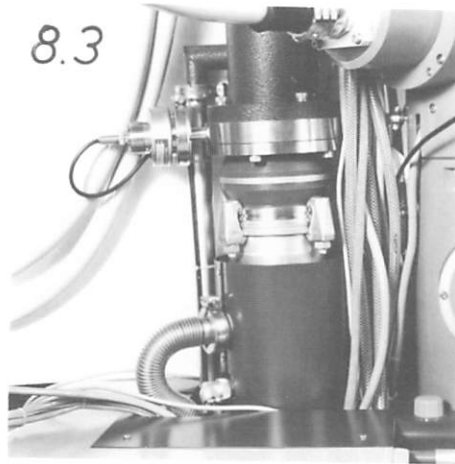
Special oil for RD 8 (1 l), Cat.No. 0084 308

Special oil for E2M8 (1.5l), Cat.No. 0119 438

8.2 Exchanging the exhaust filter

The filter insert (ceramic cylinder) should be exchanged once very year. The filter housing is opened after loosening the 4 screws in the lid.

8.12



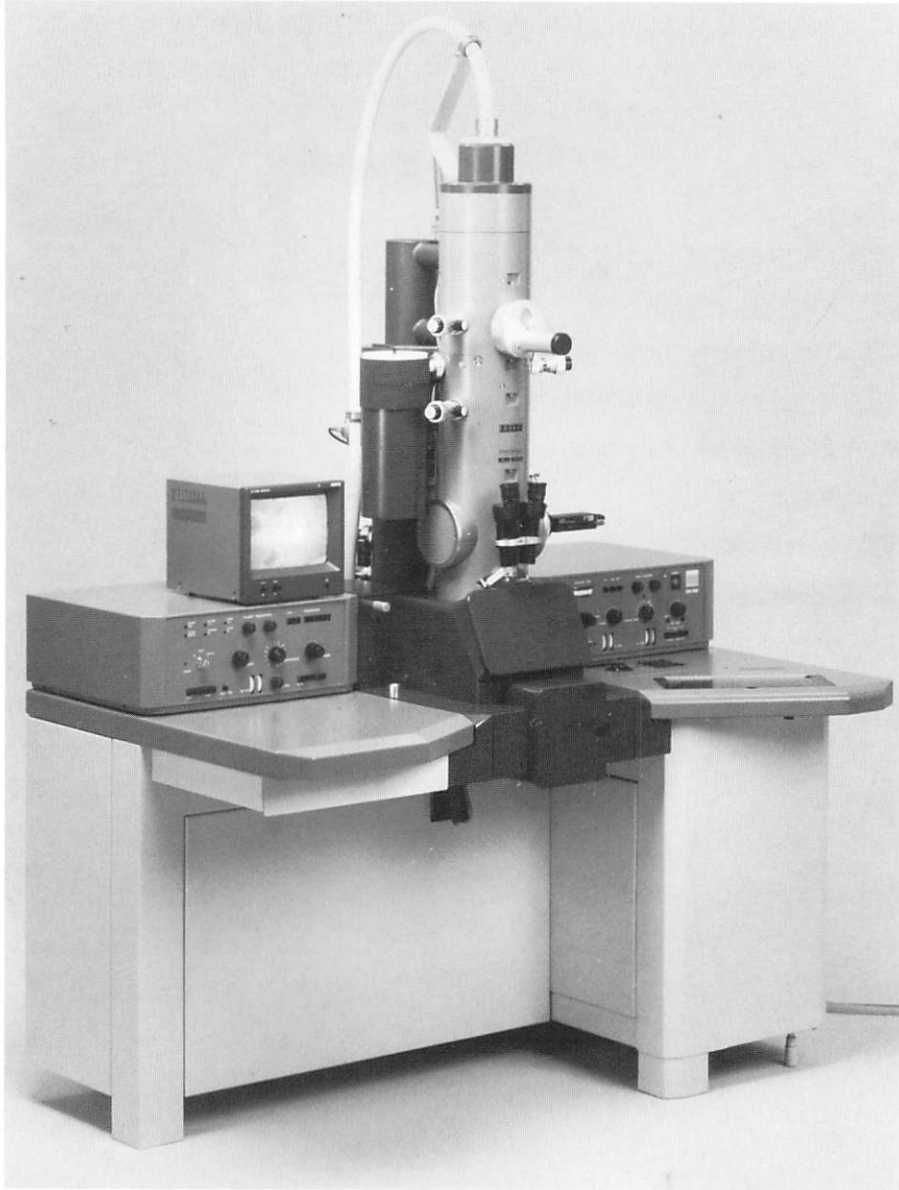
8.3 Service and maintenance of the turbomolecular pump

The pump should be serviced under a service contract by a service technician after 5000 operating hours or once every year.

Call a service technician if disturbing vibrations occur during operation of the instrument with the turbomolecular pump, or if the sound of the pump changes considerably within short time and vibration increases. For a full description see the relevant PFEIFFER operating manual.

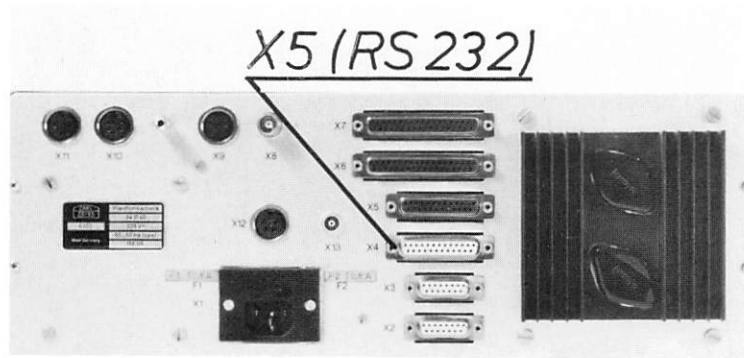
9.0 EM 900 interface description

Chapter		Page
1	General information	9.0
2	<u>RS 232 serial interface</u> Connection printer/sheet-film camera	9.2
3	<u>RS 232 serial interface</u> Control of sheet-film camera	9.4
4	<u>RS 232 serial interface</u> Control of electronic stage positioning	9.9
5	<u>TV connection for on-line image transmission</u>	9.12



Chapter 1: General information

The interfaces for the EM 900 serve to call instrument parameters for documentation and for the remote control of specific instrument parameters by an external computer. The Videoplan system is recommended as external computer, for which application-specific software is offered, including optimum utilization of the remote-control capacity. Other systems connect via interfaces described below.



Chapter 2: RS 232 serial interface for connection printer/sheet film camera

The interface belongs to the base instrument and is used to retrieve the data which are imprinted on the negative. The printed data may be used for filing. Serial printers with the following specifications are compatible:

9600bd, factory-adjusted

(a change from 600bd to 76800bd can be made by a service technician)

8 data bit

2 stop bit

no parity

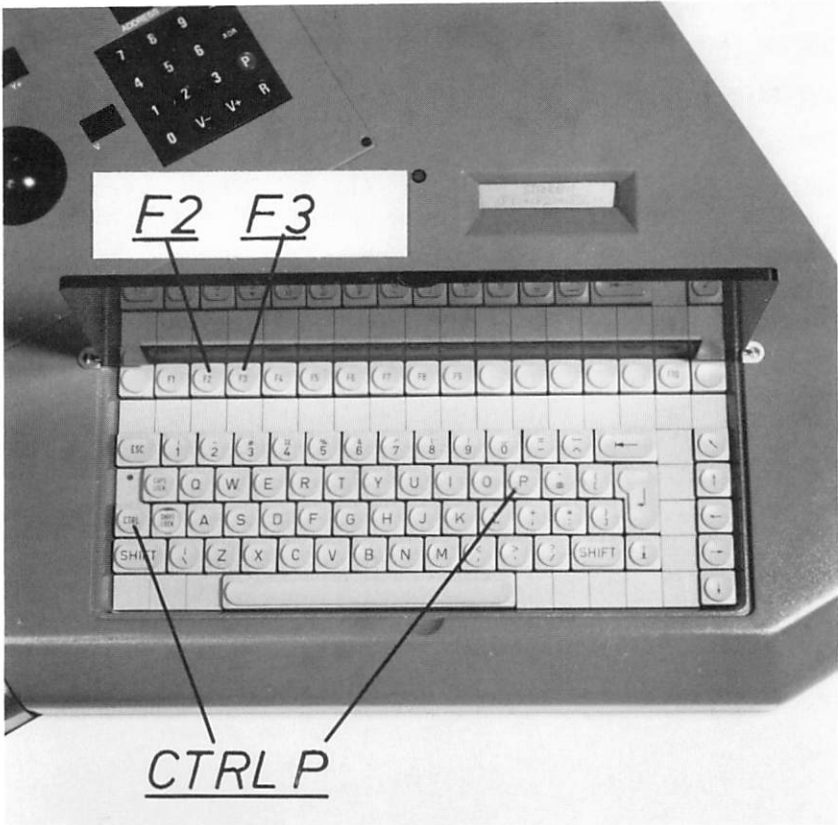
Connector assignment:

7 Ground

2 Transmitter

3 Receiver

The printer connects to socket X 5 on the back of the power supply for the sheet-film camera.



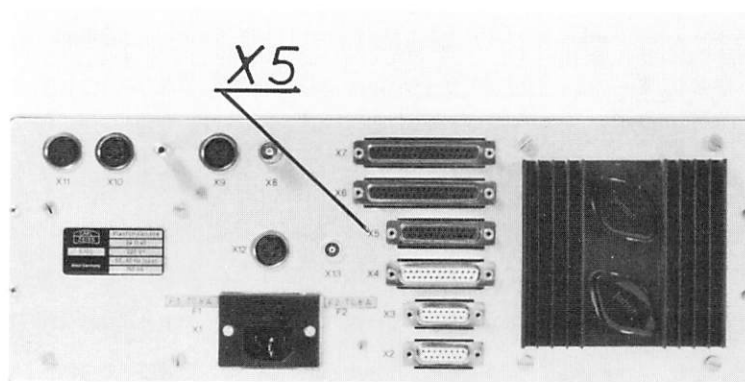
Operation

- 2.1 Switch on printer.
- 2.2 Push CTRL P on the panel of the sheet-film camera. This activates the printer which acknowledges by a line of plus signs.
- 2.3 Start exposure. The printer prints all data (without μm scale bar) after each exposure. Display of the data with the function keys F2 and F3.
- 2.4 When CTRL P is pushed twice the printer activation is cleared. The printer acknowledges by a line of minus signs.
- 2.5 Switch off printer.

Example of a printout:

```

Printer
+++++activated
RB 002035 080886 E-coli Bakterien M50000 U80-0000 I17E-11
RB 002036 080886 E-coli Bakterien M50000 U80-0000 I16E-11
RB 002037 080886 E-coli Bakterien M50000 U80-0000 I53E-12
RB 002038 080886 E-coli Bakterien M50000 U80-0000 I16E-11
RB 002039 080886 E-coli Bakterien M50000 U80-0000 I25E-11
RB 002040 080886 E-coli Bakterien M50000 U80-0000 I14E-12
RB 002041 080886 E-coli Bakterien M50000 U80-0000 I32E-12
RB 002042 080886 E-coli Bakterien M50000 U80-0000 I48E-12Activa-
-----tion
clear
```



Chapter 3: RS 232 serial interface
Control of sheet-film camera

Access to the interface only via interface adapter 34 11 40-9023. The interface serves to retrieve instrument data and to remote-control the sheet-film camera.

Operating mode: Factory-adjusted 9600bd. (Change from 600bd to 76800bd by a service technician.)

8 data bit

2 stop bit

no parity

Connector assignment:

7 Ground

2 Transmitter

3 Receiver

Connection

An external computer connects via interface adapter to socket X 5.

Operating commands for remote-control mode

Data transmission: It is made in echo mode, i.e. each character sent by the sheet-film camera is sent back as an echo by the external copmputer and vice versa, eliminating errors in the data transmission.

3.1 Retrieval of loaded film

RV retrieves the loaded film.

PK (sheet-film/plate camera) replies by:

XX = loaded film amounts to XX (2 figures).

3.2 Measurement of the camera target current and output

RI requests measurement

Possible replies of PK:

E01 = Large fluorescent screen not raised, measurement impossible.

E0 = Fluorescent screen raised, measurement made.

XXE-XX = Data format of current in exponential form using 6 characters.

The current is measured over 9 decimal powers and the total range must be divided into 3 ranges of 3 decimal powers each. There is no waiting time when measuring within a measuring range, but a change between measuring ranges may cause a waiting time of max. 2s.

For the first call of a mode switch through the corresponding measuring channel and wait for approx. 1s; only then can measurement be started. If one and the same mode is called several times in succession, only the first call will cause a waiting time.

3.3 Transfer of I_0 current into main menu

RC = I_0 current measured and copied into main menu (last 6 characters of first line)

PK replies by:

E01 = Error message: fluorescent screen not raised, measurement not possible.

E0 = Fluorescent screen raised, error eliminated and measurement made.

0 = Acknowledgement signal indicating execution of the function.

3.4 Output of user identification, frame number, free input field and microscope data

RD = Call for data output

PK replies by:

XX = User identification (2 alphanumeric characters)

XXXXXX = Frame number (6 numbers)

XXXXXX = I_0 current value (only if previously input, otherwise free input field with 6 alphanumeric characters)

XXXXXXXXXXXXXXXXXXXX = Free input field (16 alphanumeric characters)

MXXXXXX(--).X = Magnification and length of scale bar (max. 15 characters)

or

DXXXX mm = Camera length in D mode of the electron microscope (max. 8 characters)

UXX-XXXX = Accelerating voltage (kV) and energy loss (eV) (8 characters)

YYe-XX = Camera target current (6 characters)

3.5 Start of exposure

RP = Request to start exposure

Possible replies by PK:

0 = Everything alright, exposure made

Error messages:

E01 = Large fluorescent screen not raised, start of exposure not possible (*).

E0 = Fluorescent screen raised, exposure is started.

E02 = No more loaded film; remote control interrupted.

E03 = Three attempt to transport a cassette into exposure position fail; remote control interrupted.

E04 = Transport mechanism blocked; remote control interrupted.

E05 = Exposure time <0.2s; remote control interrupted.

E06 = Exposure time > 100s; remote control interrupted.

E07 = System in MDF mode, no exposure started (*).

E0 = System no longer in MDF mode, exposure starts.

(*)

E01 and E07 are errors due to instrument settings and eliminated by same. EO (ERROR OFF) signalizes that an error E01 or E07 has been eliminated. 0 acknowledges an exposure.

Chapter 4: RS 232 serial interface
Control of electronic stage positioning

Access to the interface only via interface adapter 34 11 40-9023 (OPTION).

The interface is bidirectional and serves to call the XY stage position (stored specimen coordinates). A serial printer prints the stage position.

Control for automatic retrieval of stored specimen positions and remote control of stage movement.

Operating mode: factory-adjusted 2400bd (change from 600bd to 76800bd by a service technician)

7 data bit

2 stop bit/character

ODD parity

Connector assignment:

2 Transmitter

3 Receiver

7 Ground

Operating commands for remote-control mode

(ASCII character)

S = Change to remote control

P = Retrieval of XY position (example 2)

R = Selection of XY values (example 3)

E = Reset to manual mode

The XY coordinates are entered in hex code starting with LSB not MSB.

Terminal format Display (m) Steps

Input/output

040900	=	500	=	009040	=	40000
088310	=	1000	=	013880	=	80000
001720	=	2000	=	027100	=	160000

Example 1:

X = 013850 hex coordinates

Y = 013947 in processor

X = 058310 displayed hex coordinates

Y = 749310 on terminal

Example 2:

Output of XY coordinates

	X		Y
P	X X X X X X X		X X X X X X X
Command	LSBX	MSBX	LSBY MSBY
	Reply		

Example 3:

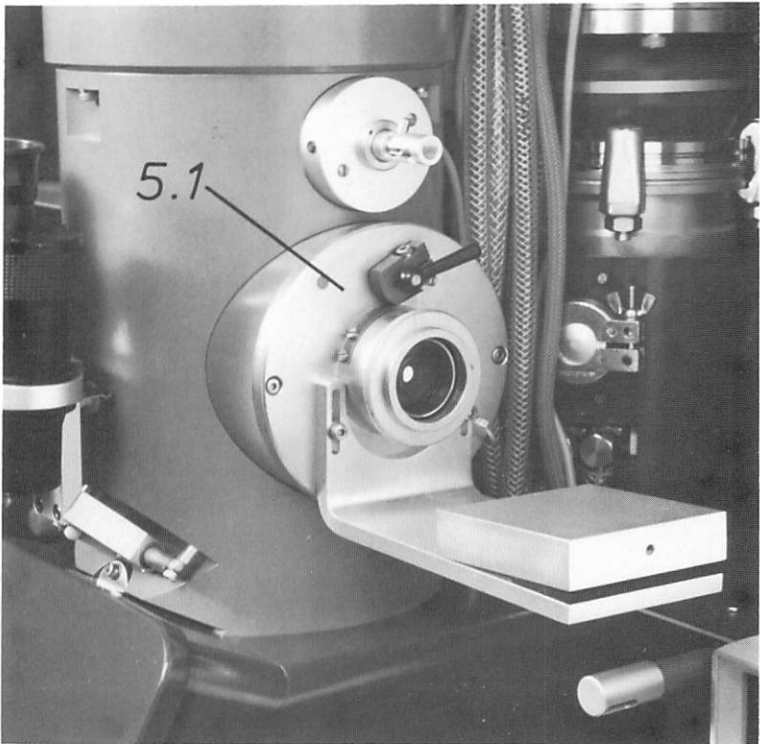
Selection of an XY position

	X		Y
R	X X X X X X X		X X X X X X X
	LSBX	MSBX	LSBY MSBY
	Command		

Example 4:

Conversion into absolute XY coordinates (in μm , 1 step = 12.5 m)

	X		Y
P	0 4 C 9 0 0		0 8 8 3 1 0
	LSBX	MSBX	LSBY MSBY
	X		Y
	0 0 9 C 4 0		0 1 3 8 8 0
	MSBX	LSBX	MSBY LSBY
	40000 steps		80000 steps
	500 μm		1000 μm



Chapter 5: TV connection for on-line image transmission

The TV chain (OPTION) comprises three groups:

- a) TV adapter
 - b) TV image intensifier camera
 - c) Monitor
- 5.1 TV adapter on shutter housing

5.1.1 Mechanical data

Position of aerial image

5.1.2 Camera connection via international C mount

5.1.3 Camera dimensions max.:

Length 300mm

Width 170mm

Height 140mm

The values of height and width refer to the camera tube axis symmetrical with the outer edges.

5.1.4 Optical data

Transmitted image diagonal > 16mm

Image scale:

- aerial image referred to detachable screen $M = 1.0$
- aerial image referred to final image fluorescent screen $M = 0.28$

5.1.5 Optical resolution

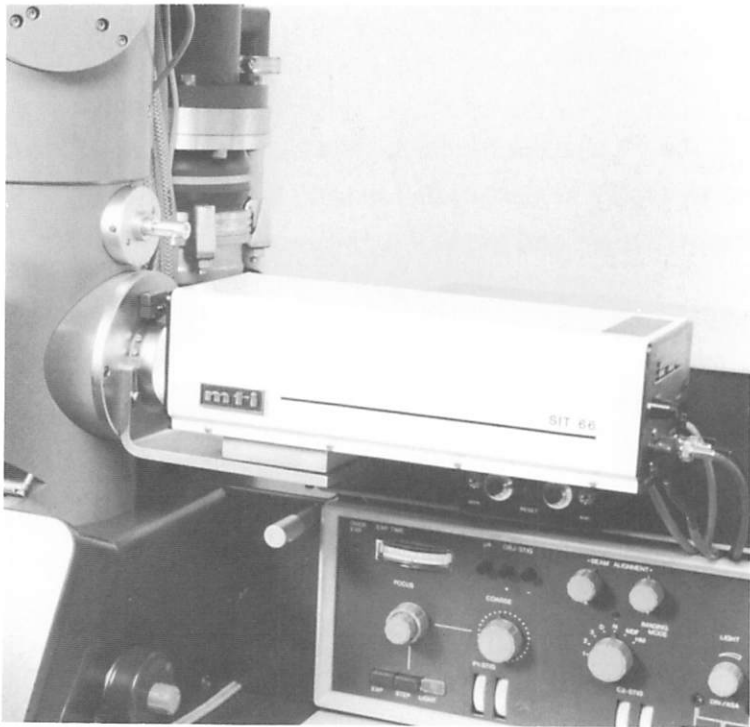
The resolution refers to the display of a 100% contrast rectangular grid with a contrast of 3.

Individual resolution:

- Fluorescent screen 60lp/mm
- Optics 100lp/mm

5.1.6 TV chain

The limits of the TV chain comprising TV adapter 34 09 53, video camera and monitor are defined by the TV system itself, primarily by the resolution of the target. The video bandwidths of camera and monitor should not lie below 10MHz.



Specifications

5.2 Electrical data

Input voltage: 195 - 260V, 50/60Hz
Vertical deflection: 50Hz, line system 625
Image tube: SIT 4804

5.3 Resolution: SIT-700 TV lines

5.4 Mechanical data

Dimensions height x width x length
(without lens): 4" x 5" x 13 7/16"
Weight
(without lens): 4.55kg
Lens mount: 16mm C mount
Coaxial connection: BNC

5.5 Environmental conditions

Ambient temperature: -20°C to +55°C SIT version
Humidity: 0 - 95%