

DSM 960 A

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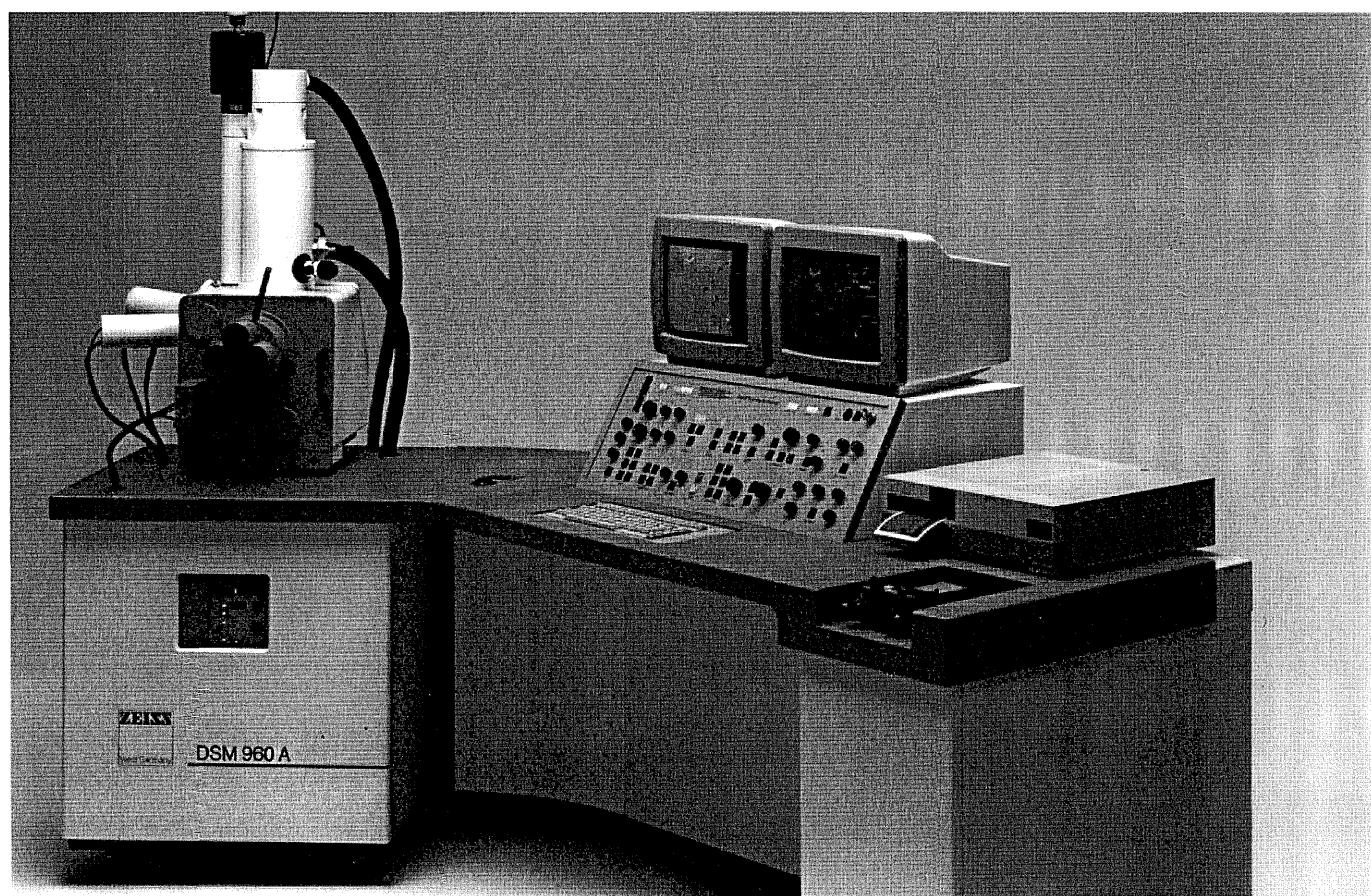
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1. Application



1.1 General

The DSM 960 A is an easy-to-operate, high performance scanning electron microscope which incorporates latest electronic technology.

Information about structure and morphology of specimen surfaces, even in the submicrometer range, is easily obtainable with this instrument.

The wide magnification range from 4times to 300,000times allows the examination of macro and micro structures.

With a comprehensive line of accessories the DSM 960 A can be perfectly adapted for specific requirements, e.g. for the analysis of micro surface areas. With these instructions even the less experienced user will be able to obtain optimum results.

This operating manual is intended to be a guide for the user to achieve best possible results with the instrument of his problem. We tried to keep the explanations as simple as possible in order to advise also a less experienced user.

1.2 Important Information

1.2.1 Important prohibitions

The following prohibitions should be strictly observed when operating the DSM 960 A.

Failure to comply with such prohibitions may damage your health or the instrument, and also forfeit any warranty claims.

- Operation of the instrument in case of frequent high-voltage sparkovers and strong instabilities.
- Force applied to stuck mechanical components (e.g. aperture changer drives, stage drives).
- To unscrew sheathings and protective cover sheets.
- To shunt safety breakers (gun), remove electrical fuses and mechanical safety locks and earth leads.
- Application of non-approved vacuum grease and pump oil.
- Extended operation of the instrument outside the installation conditions.
- To mount non-approved attachments.
- To leave data to third parties.

1.2.2 Electrical safety

The DSM 960 A is constructed and tested in compliance with VDE regulations. Each instrument is tested in the factory for compliance with VDE regulations.

This routine test minimises the risk of electric shock to the user. In spite of this certain safety precautions must be observed for the operation of live instruments.

Recommended safety installations

- Extra fuse protection by FI switch
- Emergency OFF switch

Prohibitions for protection from electric shock

- Do not dismantle sheathings on instrument and electronic cabinets (power supply, high voltage).
- Do not remove earth leads (ground cables).
- Never shunt safety switches.
- Do not provide for higher fusing of instrument.
- Do not disconnect instrument outlet.
- Do not buckle, squeeze or cut electrical supply lines.
- Do not use non-approved attachments on the DSM 960 A
- De-energise the entire system for servicing.
- Only authorised specialists are allowed to work on the electrical system.

Rules of action in case of incidents

- Instantly switch off instrument in case of burning smell or dense smoke.
- Instantly switch off instrument in case of damage caused by water.
- Switch off instrument if the circuit breakers of the power supply react frequently.

1.2.3 X-ray protection

Electron beams which strike matter generate X-rays; their intensity and hardness (wavelength) depend on the accelerating voltage, the beam current and the material they strike.

A number of active measures (beam current limitation, safety circuits) and passive protection provisions (shielding) in the DSM 960 A guarantee that the permissible maximum doses in compliance with the X-ray rules (RV) of 08-01-88 are not exceeded even in case of irregular or faulty operation. This is confirmed by the Construction approval by the PTB Braunschweig (test certificates No. 6.22-S1072, 6.22-S1073, 6.22-V143 and 6.22-V144).

In compliance with these rules the value of 1 Sv/h is not exceeded anywhere at a distance of 10 cm from the instrument wall.

Moreover, the X-ray safety of each delivered instrument is guaranteed by a routine test.

Only if the following instructions are strictly observed is the X-ray safety of the instrument maintained. The safety is lost if they are not observed.

- Do not remove any sheathings on the DSM 960 A, especially near the column.
- Do not mount non-approved attachments.
- Do not replace flanges and vacuum components.

1.2.4 Safety precautions for the use of liquid nitrogen

An accessory of the DSM 960 A - the EDX-detector - uses liquid nitrogen. It must be refilled at regular intervals to maintain cooling. The following safety precautions must be observed for the use of liquid nitrogen.

Preliminary remarks

Approx. 78% of our respiratory air consist of actually harmless nitrogen.

The use of nitrogen liquefied at a temperature of minus 196 °C may be dangerous.



CAUTION

Scalding by liquid nitrogen on the skin!

Because of the low temperature liquid nitrogen may destroy the skin severely, similar to scalding by hot fluids or burns.

Splashes or small drops of liquid nitrogen cause the generation of an insulating layer of gaseous nitrogen between skin and nitrogen drops due to the body temperature (Leidenfrost's phenomenon).

There will be no such protective effect due to Leidenfrost's phenomenon if more liquid nitrogen gets in contact with the skin or clothes are soaked. The drastic thermosteresis of liquid nitrogen on the skin will then bring about the aforementioned burn symptoms.



CAUTION

Implosion risk when pouring liquid nitrogen into glass Dewar vessels!

Dewar vessels are double-walled, with a vacuum between the walls (thermos bottle principle).

Always wear a face mask when handling glass vessels, or, better, use metal Dewar vessels. Due to their higher stability metal Dewar vessels withstand the temperature shock when pouring in liquid nitrogen.

Liquid nitrogen which penetrates the insulating space through pores or fissures of a defective Dewar vessel will evaporate due to heat absorption on the inner side of the outer wall. The vessel will explode because the gaseous nitrogen cannot escape quickly enough.

**CAUTION****Fire risk due to enrichment of liquid nitrogen by liquid oxygen!**

Oxygen liquefies already at minus 183° C, and the oxygen in the air condenses on the surface of the liquid nitrogen (minus 196° C) and enriches it gradually by liquid oxygen. At concentrations of more than 5% liquid oxygen, flammable material such as dust, paper, wood shavings or foam material will burn when falling into the Dewar vessel.

Therefore:

- Cover the vessels so that evaporating nitrogen can escape, but the entrance of air is inhibited and no flammable material can fall in.
- Use vessels with narrow neck which are also more economic because of slower nitrogen evaporation.

**CAUTION****Oxygen deficiency risk due to nitrogen enrichment of respiratory air!**

The amount of evaporating nitrogen in the workroom should not noticeably reduce the relative amount of oxygen in the respiratory air. The permissible lower limit of the oxygen content is 20 vol% (normally approx. 21 vol%).

Standard values for maximum amount of liquid nitrogen in surface rooms

- Enclosed room with windows and doors: 1.5l/cubic meter room volume
 - Naturally aired room: 30l/cubic meter room volume
 - Constantly air-conditioned room: 150l/cubic meter room volume
 - Liquid nitrogen may be used or stored in subterranean rooms only if a controlled mechanical ventilation is available
- or
- evaporated nitrogen which because of its higher density accumulates at the ground or in depressions is able to drain off without damage.

1.2.5 Maintenance

The following maintenance instructions for the DSM 960 A should be strictly observed to maintain use ability and reliability of the instrument.

Regular care and maintenance of the DSM 960 A include

- check of all functions (mechanical, electron-optical, electrical, electronic, vacuum system and cooling system), and
- reliable execution of all prescribed cleaning and servicing measures.

Care and maintenance should eliminate disturbances so early that they do not have any noticeable effect.

Checks and service of the DSM 960 A should be carried out at regular intervals by our specifically trained Technical Service, on the basis of a service contract concluded with Carl Zeiss.

Care and maintenance work of the DSM 960 A which may be carried out by the user himself are described in chapter 5 of this manual.

This also concerns the replacement of expandable parts as far as simple tests and auxiliary means permit.

Important notes on the maintenance



CAUTION

To prevent the user from being endangered by electric shock, all parts carrying dangerous voltage are covered. It is prohibited to remove sheathings and open the instrument.



CAUTION

Electrical repair and maintenance work should be carried out only by specifically trained, qualified personnel.



CAUTION

All safety precautions for the use of liquid nitrogen, for protection from X-rays and electrical safety must be strictly observed. See previous paragraphs of this manual.

Cleaning

The DSM 960 A should be kept meticulously clean, in particular:

- Worktable surfaces and specimen holders should be clean and dust-free to prevent contamination of specimen and specimen chamber.
- All parts which are inside the vacuum or brought into it must be handled with care. Wear lint-free gloves to manipulate the parts to prevent grease and sweat. Use tweezers to hold small parts and specimen holders.
- Use only approved solvents for cleaning.

Maintenance

- The instrument should be serviced at the prescribed intervals and with the necessary care.

The following servicing should be made at regular intervals and/or if necessary:

- Filament and anode replacement
- Cleaning of electrodes and condenser liner tube
- Aperture exchange
- Care of vacuum pump (rotary pump)

1.3 Delivery and installation

1.3.1 Equipment supplied

The DSM 960 A is supplied in 2 wooden containers:

Container 1: electron-optical column,
chamber stage, frame with vacuum system.

Container 2: electronic console,
rotary pump,
pump tubing and
vibration isolator.

Hoses two hoses (10m length, 6mm inside diameter)
for cooling water,
one (10m length, 4mm inside diameter)
for nitrogen gas.

Connection cable
In Germany the instrument is
supplied with CEKON plug.

The equipment also includes:

Set of tools

1	aperture plunger
1	pointed tweezers
1	specimen stub tweezers
1	pressure pump
1	filament alignment device
1	blind bolt
1	screwdriver for stub holder
3	stub holders (15 ,30, 50 mm)
1	Allen key for camera adjustment sw 5
1	scintillator changer
1	Allen key for specimen clamping sw 1,5
1	Allen key for gun cap sw 2,5

Expendable material

10	filaments
25	specimen stubs
1	scintillator
1	set of apertures (40, 120, 160, 200 µm)
20	retaining rings
2	Wehnelt apertures
1	set of fuses (1/1.4/2/4/6.3A)
1	specimen box
1	bottle of polishing cream
5	wooden sticks

Manuals

for DSM 960 A
for Rotary pump
for 4"x5" Polaroid film holder
for Turbo molecular pump

1.3.2 Installation requirements

Room size

(bulky accessories not considered!)

Minimum room size:

3m x 3.5m;
Minimum ceiling height:
2.30m.

The largest single item is the electronic console.

Dimensions:
1.40m x 0.78m.

All relevant doors and passageways should have a minimum width of 0.80m; crooked passageways must be wider.

Floor

Solid, preferably concrete floor.
No cast plaster or carpeted floor under the column.
Carpeted floor should be cut out and replaced by solid base plates.
Antistatic coating only.

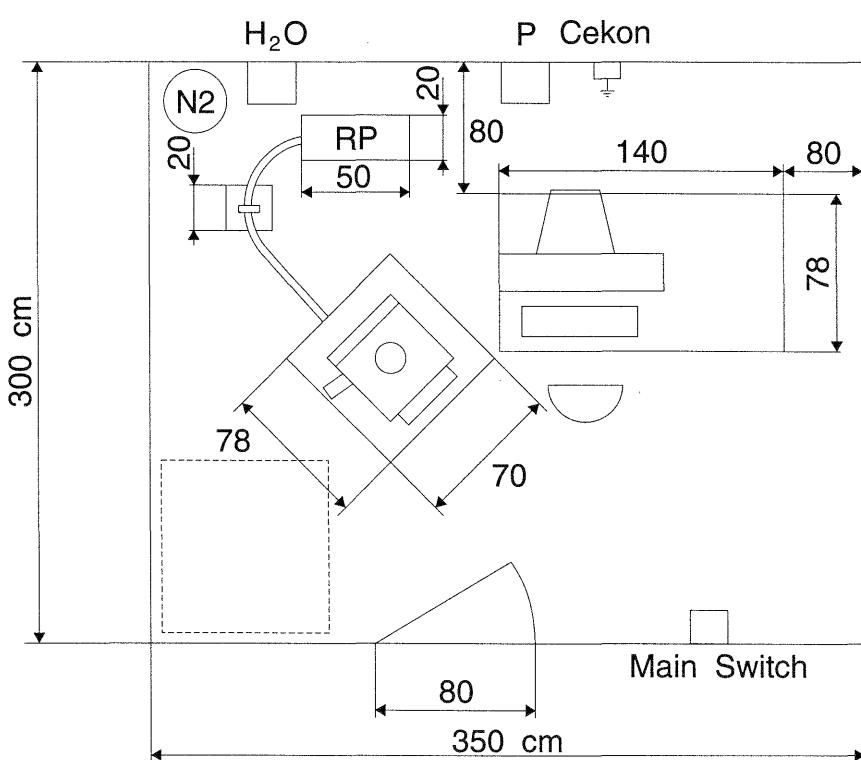
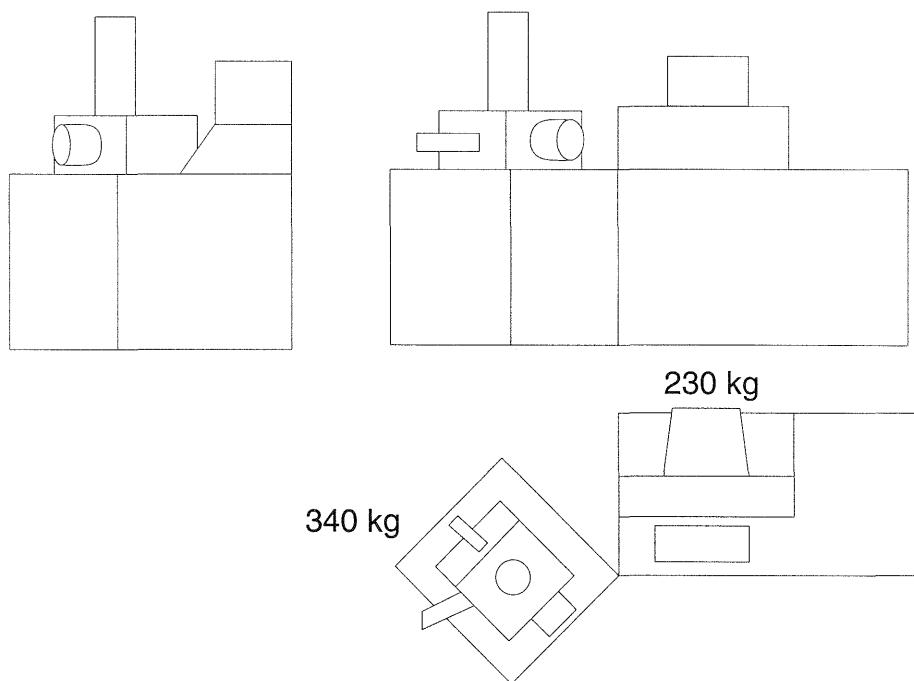
Vibrations

Vibrations of the building should be measured in time before installation of the instrument.

Values of max. $3\mu\text{m}$ (peak-to-peak) at frequencies above 15Hz are permissible. If different readings are found we will be happy to advise you.

Stray magnetic fields

The installation facility should be examined for magnetic stray fields prior to installation.
The maximum permissible magnetic stray field in the room is $3 \times 10^{-7} \text{ T}$ (peak to peak) = 3 mG (peak to peak) = $2,3 \text{ mA/cm}$.
Maximum reading on the stray field meter SFM3:
 1.1 mG (rms value reading 50 Hz - 5 kHz).



1.3.3 Installation

Ventilation

Recommended room temperature:	+15 °C to +25 °C.
Max. relative humidity:	< 60%. Approx.
Air exchange	1.5 kW heat emission of the DSM 960 A should be eliminated by air exchange (base equipment without accessories).
	No darkroom work in the DSM room because of danger of corrosion by vapors from fixative baths.

Illumination

The room need not be darkened completely, but a dimmer is recommended. For service work bright light should be provided.

Power requirements

The connected load of DSM 960A is 3 kVA. The supply voltage is 190 V to 240 V (50..60 Hz). The customer must provide a line connection which complies with the local regulations (P).

A CECON connection for 32A is recommended:

Wall outlet: CECON 6UR3/206-2 (Siemens)
Plug: CECON 6UR3/276-2 (Siemens)

Main switch
The main power switch for the instrument should be easily accessible,
preferably next to the door.
For the power supply line: 25A circuit breaker with fusing characteristic slow blow.

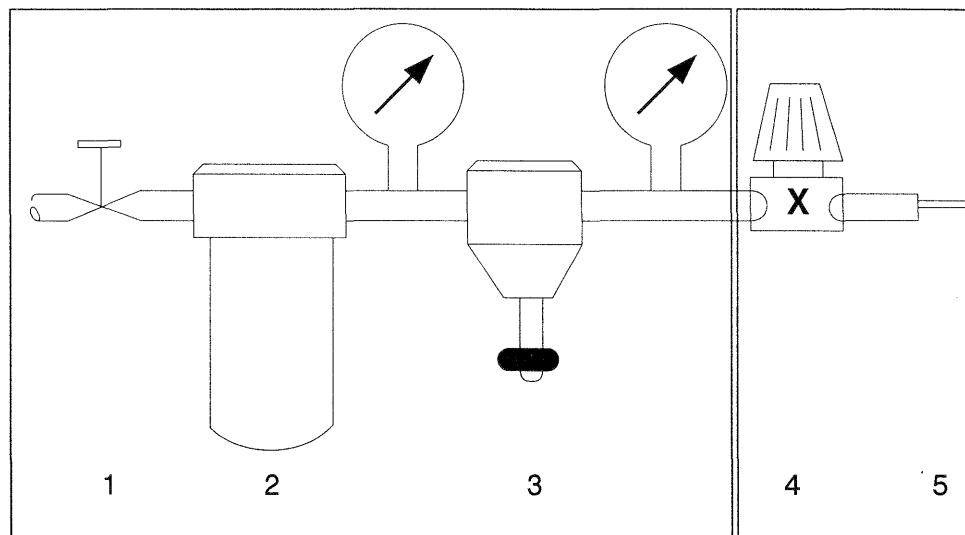
Protective ground



The DSM 940 A is subject to the regulations for high-voltage installations.

The instrument must therefore connect to a 2nd safety ground connector or an equipotential connection via a separate line of at least 4 mm cross section, unless the local regulations are different.

Cooling



Cooling water is required for the DSM 960A for the operation of the turbomolecular pump, the electron-optical lenses, and the electronic power elements. Cooling is by a recirculating cooling system or from the general water supply. The heat output into water is approx. 1 kW. The DSM 960 A needs a flow rate of 2 litres per minute. This can be adjusted from recirculating cooling systems without any problems. When the cooling is from the general water supply a filtering unit with pressure regulator and magnetic water valve is required which shuts the water off when the instrument is switched off in order to avoid condensation.

The minimum flow rate is 2 l/min. Input pressure is 2 bar and may not exceed 3 bar. Minimum temperature of the water is 16°C, the maximum is 25°C.

a) Recirculating cooling system:

The system may be air- or water-cooled.

It is available from Zeiss. The air-cooled system should be installed outside the SEM room in a way that the dissipated hot air can be carried away. Because of the noise the water-cooled unit should also be installed outside the room. Each unit of the recirculating cooling system requires an outlet of 220 V, 16 A at the point of installation. A 2nd outlet should be available for service purposes. The water-cooled compressor unit also requires tap water without filtering and a water sink. Tap water consumption is controlled by the system and amounts to approximately 100 l/h at maximum cooling power.

The recirculating cooling system can be controlled from the DSM 960 A. A control power line (3 x 0.75 mm²) must be available for the purpose.

b) Cooling from general water supply:

The cooling water must be pressure-controlled and filtered. The customer must provide for these fittings:

- Main valve (1)
- Water filter (2)
- Pressure regulator with 2 manometers (3)
- Magnetic water valve (4)
- Tubing 6 mm (5)

The assembly of positions 1, 2, and 3 is considered a suggestion and may be ordered under ordering number 340900-8904. The magnetic water valve plus the tubing (positions 4 and 5) are available under ordering number 348317-9001.

The magnetic valve is controlled from the DSM 960A.

The water is drained into an open sink.

Venting

Dry nitrogen must be available for chamber and pump venting during specimen exchange; it may be supplied from a nitrogen cylinder with pressure reducing valves with hose connectors for 4 mm inner diameter (N2).



The minimum pressure should not fall below 0.2 bar; otherwise the time for the chamber venting will be quite long. The maximum pressure must be limited 0.3 bar.

Nitrogen consumption with open chamber is approximately 3 l/min at a pressure of 0.2 bar above ambient pressure.

The nitrogen-gas should be 99.996% pure.

Exhaust of rotary pump

When evacuating the scanning electron microscope the gas exhaust of the rotary pump is carried away by an exhaust line.

This line must be installed starting at the rotary pump and ending outside the building if possible.

The exhaust line should consist of PVC tubing with an inner diameter of 10 mm.

Instead of an exhaust line an oil mist filter may be installed (ordering number 345571-0000).

Compressed air (only if Auto Levelling Anti Vibration System is installed)

Compressed air with 6 bar pressure is required for the auto levelling anti vibration system. Consumption is during levelling only and thus very low. The compressed air can be supplied from a cylinder with pressure reduction valve. A compressor is available under ordering number 345596-0000. The inner diameter of the hose is 6 mm.

1.4 Basic Instrument:

Resolution

4 nm	- guaranteed with tungsten filament at 30 kV, 6 mm working distance, specimen untilted
25 nm	- obtainable with tungsten filament at 1 kV, 6 mm working distance, specimen untilted
3.5 nm	- guaranteed with optional LaB ₆ gun at 30 kV, 6 mm working distance, specimen untilted

Accelerating Voltage and Beam Current

0.49 kV - 5 kV	- selected in fine 10 V steps and coarse 1 kV steps
5 kV - 30 kV	- selected in fine 1 kV and coarse 5 kV steps

All electron optical parameters are high-voltage-compensated

Probe current: - 1p A to 3 µA at 30 kV, W-filament

Current stability: - down to 0.1 %/h

The high voltage is double vacuum interlocked with auto-shut-off for safety

Electron Gun

- Precentered tungsten hairpin filament mounted in plug-in Wehnelt assembly
- Active emission current control with independent Wehnelt voltage supply
- Emission image by push button control with instant return to original microscope conditions
- 2-stage electro-magnetic beam alignment with a single pair of X/Y controls
- Continuously adjustable filament current with on-off push button and with digital readout
- Continuously adjustable emission current with digital readout
- The filament current is vacuum-interlocked
- Unique gun design eliminates the need for Wehnelt-anode spacing adjustment and ensures optimum results over the entire voltage range
- Automatic warm-up routine for optional LaB₆ filament

Lens System

- Computer-designed, electro-magnetic three-lens system, microprocessor controlled
- Precision machined electron optical parts
Water-cooled lens system for best thermal stability and reproducibility
- 45° conical objective lens for high tilt angles with large specimens at short working distances
- Double condenser zoom system for easy change of spot size and specimen current while retaining focus
- High voltage compensation for constant focus
- Automatic compensation of hysteresis of magnetic lenses with coarse accelerating voltage adjustments
- Hysteresis compensation may also be initiated by function key

Column

- Compact column design plus double Mu-metal shielding limits sensitivity to stray magnetic fields
- Factory-aligned column for minimum astigmatism and minimum beam shift
- Maintenance of column is minimized by use of an easily removable and disposeable liner tube

Apertures

- The liner tube holds 3 molybdenum spray apertures
- 4 final apertures, individually replaceable, special exchanger tool provided
- 40 µm thin film aperture plus 70 µm, 120 µm, 200 µm molybdenum apertures
- Apertures of 400 µm and 1000 µm may be mounted
- Apertures externally selectable with precision click-stop mechanism and alignable under vacuum
- Focus wobbler with adjustable amplitude aids in aperture alignment

Astigmatism Correction

- Octopole electro-magnetic X/Y-stigmator system for compensation of residual astigmatism at magnifications above 10 kx
Compensated for high-voltage changes

Beam Shift

- Electro-magnetic beam shift for fine alignment of the raster on the specimen at high magnifications
- 15 µm in X and Y at 25 mm working distance

Specimen Chamber

- Extra large specimen chamber with 270 mm width, 310 mm depth, and 270 mm height for large specimens
- Chamber walls are nickel-plated for vacuum integrity and baked out after final assembly
- Flanges for SE-, BSE-, CL-detectors, X-ray spectrometers, CCD-TV-camera with illumination are provided on the chamber.
- BNC-connector for specimen current measurements
- Front door with stage rolls open giving ample access to the stage and the chamber interior.
- Front door seals with greaseless viton O-rings
- 35° take-off angle at 25 mm working distance for EDX- and WDX-spectrometers for simultaneous operation

Specimen Stage

Two types of stages are alternatively available:

Standard Stage:

- Eucentric high precision stage with X and Y total travel of 25 mm with position indicators
- Z motion range of 25 mm plus coarse setting by spacers 10 mm, 25 mm, and 30 mm
- 360° continuous rotation
- Tilt range from -15° to +90°
- X/Y motion and rotation is in the plane of tilt (eucentric design)
- Specimen platform is electrically insulated from chamber ground
Damage to the specimen is prevented by a touch-activated buzzer which sounds on contact with chamber parts

or

Macro Stage

- Eucentric high precision stage with linear X and Y total travel of 80 mm with position indicators
- Z linear motion range of 30 mm with position indicators plus coarse setting by spacers 15 mm, 30 mm and 50 mm
- 360° continuous rotation with position indicator
- Tilt range from -15° to +90°
- X/Y motion and rotation is in the plane of tilt (eucentric design)
- Specimen holder accepts 5 standard specimen stubs
- Specimen platform is electrically insulated from chamber ground
Damage to the specimen is prevented by a touch activated buzzer which sounds on contact with chamber parts

Motor Controls for Macro Stage

- Manual control knobs for the drives
or
- Motorized control of X, Y for the eucentric stage with trackball control for X/Y, magnification compensated motions, travel X/Y = 75 mm
- Store and recall of 120 stage positions
- Frame advance of stage with cursor keys
- 12 mm/s translation speed in X and Y
- Electrical travel limitations and reference setting
- Motorized control for Z, travel Z = 25 mm
- Motorized control for Rotation

Chamber Doors

- For the Standard Stage with or without 3 flanges
- For the Macro Stage in three different mounting heights of the tilt axis at 25 mm, 50 mm (standard), 100 mm, with or without flanges option on each version

Back plates

- Standard back plate prepared for EDS-adaption and CCD-camera
or
- Back plate prepared for EDS/WDS adaption

Vibration Isolation System

Column and chamber are pneumatically vibration isolated.
2 systems are available:

Standard System

- 4 individually inflated bellows allow levelling

Autolevelling System

- Sensors detect the level and control the level through a valve system automatically.
Compressed air is required for this system.

Vacuum System Standard system:

- Water-cooled 240 l/s turbomolecular pump for hydrocarbon - free vacuum backed with a 8m³/h two-stage rotary pump
- One-stage pumping system design protects delicate specimens from sudden pressure changes
- Microprocessor control for fully automatic and fail-safe operation. Vacuum interlock is released at 2 x 10⁻⁵ hPa, LEDs show pumping status
- Continuous monitoring of vacuum system operation with emergency shut down and error display
- Vacuum interlock circuit for safe operation of windowless EDX-detector or WDX-spectrometer
- Chamber vacuum is measured by Penning gauge and shown on a calibrated bar display
- Automatic ventilation with dry nitrogen
- Sealing surfaces are machined to 6 m roughness, eliminating the use of vacuum grease
- Viton is used in all O-ring seals, resulting in a base pressure of 2 x 10⁻⁷ hPa
or
- Differential gun pumping system with column isolation valves and ion getter pump

SE-Detector

- Scintillator-type SE-detector with continuously variable collector voltage
- Backscattered electron image selected by single push button to reverse collector voltage
- Optimized collector geometry allows observation of untilted specimens at very short working distances with maximum signal
- Detector is mounted such that manipulation of large specimens is unimpaired
- Real-time simultaneous automatic contrast and brightness control system with alternative manual operation
- Functional in all scan modes
- Brightness and contrast meters for manual control

Signal Inputs

- Push button selection from 5 signal sources (SE, BSE, EDX, and 2 auxiliary inputs for additional detectors like CL etc.)
- Contrast inversion, push button selectable

Menu selection for EDX/WDX inputs:

- 3-channel input from EDX system for area mapping
- 1-channel input from WDX-system for area mapping
- 3 channels can be programmed for simultaneous red, green, and blue display of maps
- EDX-and WDX- maps can be shown together
- Count rate threshold selection from 1 - 9 for background suppression
- 1-channel input for EDX-ratemeter or WDX-ratemeter for concentration profile registration
- a line in the image indicates the position of the concentration profile on the specimen

Display

- 14 inch, 0.28 mm pitch TV color monitor for monochrome and color display
- Monochrome display may be set to gray or green

Deflecting System

- Special saddle coil system for distortion-free images in slow scan and TV mode over the entire magnification range with excellent low magnification performance (less than 1% at 20x with TV or Slow Scan)

Magnification

- 15x to 300 000x at 7 mm working distance
- Fixed steps in 1-2-3-5-10 sequences
- Minimum magnification: 4x at 50 mm working distance
- Zoom over the entire magnification range
- Compensated for changes in working distance and high voltage
- Magnification display on front panel and in the image data field
- Bar marker with length annotation in the data field of the image
- Programmable preset magnification for instrument start-up
- Programmable reference magnification with toggle by a function key between actual magnification and reference magnification
- Magnification is calibrated to 4 x 5 inch photo format

Focus

- Digital focus with encoder knob
- Coarse and medium sensitivity selectable by push button
- Additional 10-turn fine focus knob
- Accurate microprocessor calculation of working distance from focus setting
- Working distance display on the front panel and in the data field of the image
- Programmable preset working distance for instrument start up
- Programmable reference working distance with toggle by function key between actual working distance and reference working distance
- Dynamic focus with continuous control for tilted specimens

Scan Modes

The images can be collected directly into a frame store

TV mode:

- Standard NTSC or CCIR scan rate

Slow scan modes:

- 512 x 512 pixels/frame, 1s - 340 s scan time
- 8 scan acquisition time settings with pixel integration
- Single frame scan at longer scan times
- Reduced area scan 1/16 frame, fixed in center
- Variable reduced area scan adjustable in X/Y-size and X/Y position
- Line scan at frame times, line adjustable in Y, accurate to 1% of frame width
- Y-modulation for frame with 48 lines from video signal, 100% contrast gives a deflection of 25% of screen height
- Y-modulation for line scan with X-ray or video, 100 % contrast gives deflection of 25% of screen height
- Autoranging for video signal
- Operates as a waveform monitor in the 1s fast scan
- At slower scan rates the Y-modulation can be overlaid on the specimen image
- Multiple line scan can be clearly displayed on the same image
- Spot mode with adjustable position in X and Y with crosshair indicator in overlay, accurate to 1 % of frame width
- Splitscreen with dual magnification (1x, 2x, 4x, 8x)
- Dual signal input selectable from 5 signal sources
- Scan rotation with angle memory through 360, continuous increment 1, with digital angle display
- Tilt compensation with variable amplitude
- Fully automated gun emission image with push button control

Frame Store

- 250 kB frame store
- Image has 512 x 512 pixel, 256 grey levels (8 bit)
- Separate overlay plane for user and system-generated annotation

- | | |
|-------------------------------|---|
| Data presentation | <ul style="list-style-type: none">- Data field contains magnification, micron marker bar with length annotation, high voltage, working distance, photo number, label, logo, and motor stage information- Label and logo are freely editable- Text entry into the full image area with standard QWERTY-type keyboard- Special characters and symbols (arrows, , etc.) provided- Overlay clear function |
| Image Recording | <ul style="list-style-type: none">- Fully calibrated automatic exposure system:- The contrast and brightness levels for the recording system are referenced to those on the visual monitor (WYSIWYG-principle)- 5 x 9 setting values for exposure control definable by the user- 9 preset exposure settings for commonly used film types from Zeiss- 3 test patterns for camera setup and focusing- 2 test patterns for exposure setup (gray scales) |
| On-line recording: | <ul style="list-style-type: none">- 5 on-line recording speeds at 2048 x 2048 pixels per frame- 6 on-line recording speeds at 1024 x 1024 pixels per frame |
| Frame store recording: | <ul style="list-style-type: none">- Fast recording of image in 15 s- High resolution CRT with 2500 lines full size resolution- Highly linearized scan with dynamic focus for sharp focus- TV interface with NTSC- or CCIR-standard for output on video tape recorders, additional video monitors, video hardcopy systems, or TV-based image analysis systems |
| Camera | <ul style="list-style-type: none">- Built-in lens for film backs, removable- Back plate and lens are adjustable to accommodate other film formats- Remote control interface for automatic shutter and film advance- Instant film camera back 4 inch x 5 inch |

Operating System

- Computer Control:
The microscope is controlled from a multi-processor, multilevel operating system
individual microprocessors monitor and regulate specific instrument functions
- User Interface:
Routinely used basic functions are One-Knob/One-Function arrangements
Parameter settings through special menus on monitor

Safety features

- Fully protected against power line failure
- Internal power supply watchdog circuit with supply rail indicator LEDs
- Water failure circuit with indicator lamp on front panel and emergency shut-down
- Continuous monitoring of vacuum system operation with emergency shut-down and error display

Environment

Electrical power	190 V - 240 V 50...60 Hz, 3 kVA
Water	2 l/min at 2 bar max. 3 bar
Dry Nitrogen	2 l/min at 0.2 bar over ambient pressure for ventilation
Compressed air	6 bar (for autolevelling system)
Room temperature	20 - 30 degrees Celsius (68 - 86 F)
Relative humidity	less than 65 %
Vibration	< 3 μm_{pp} $\geq 15 \text{ Hz}$
Stray magnetic field	< 3×10^{-7} Tesla _{app} , 50/60 Hz, sinusoidal

Dimensions and Weight

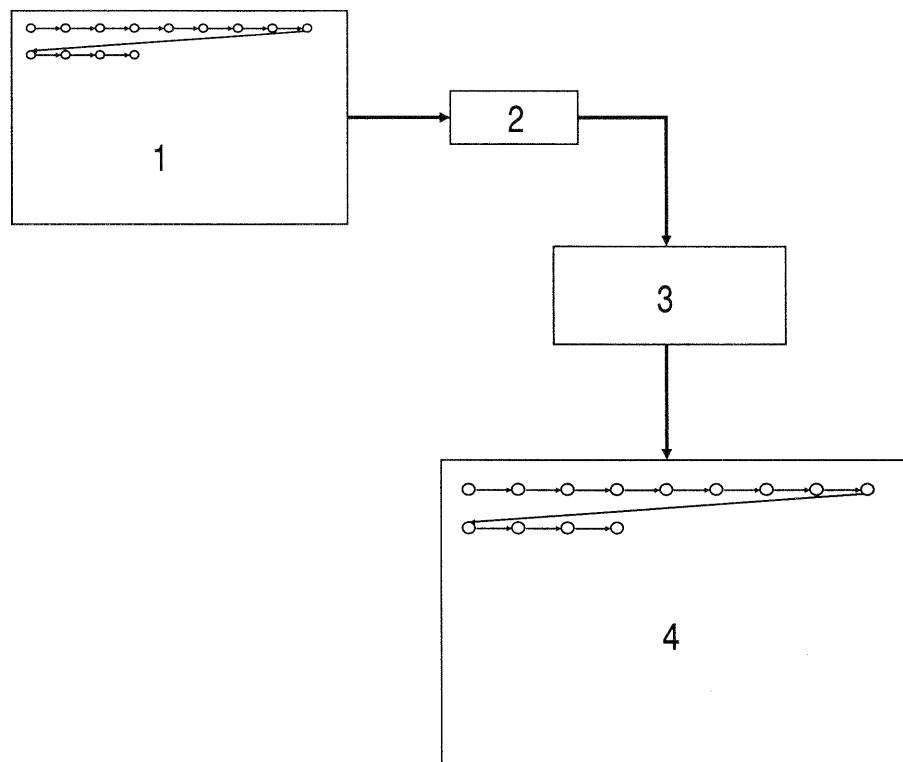
	wide	deep	height	weight
Column unit	70 cm	78 cm	165 cm	340 kg
Console	140 cm	78 cm	135 cm	230 kg



**The specifications apply to the basic instrument only.
Attached accessories may change the specified data.
Data is subject to change without notice.**

2. Operating principle

2.1 Principle of the scanning electron microscope



- 1) Specimen surface
- 2) Detector
- 3) Video processing
- 4) Monitor screen

The specimen is scanned point-by-point in a specific pattern by a narrowly bundled electron beam, and a signal is released by each pixel on the specimen surface. These signals are picked up by suitable detectors and evaluated.

The total of all signals of the scanned pixels produce an image of the scanned field on a monitor.

2.1.1 Beam path

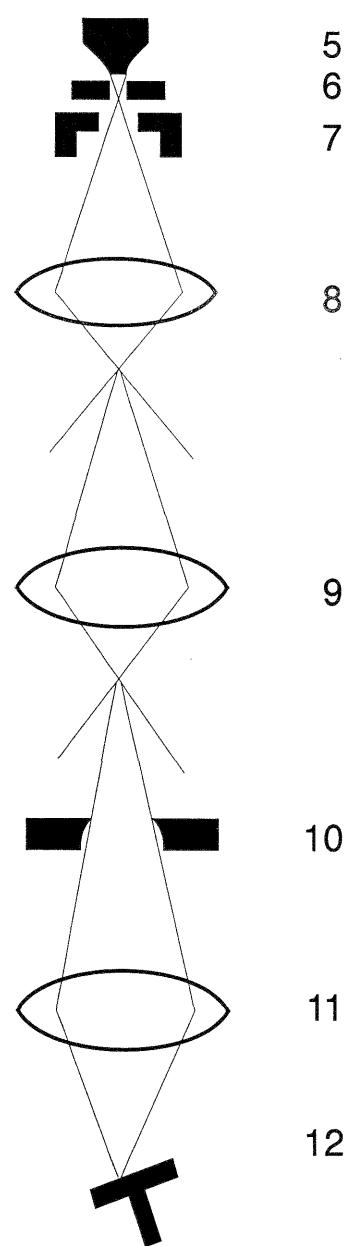
Electrons are emitted by a filament (5) - generally a heated tungsten wire - and picked up by an anode (7). The emitted electron current is controlled by a Wehnelt cylinder (6). The cathode assembly (filament and Wehnelt cylinder) and the anode are arranged so as to produce a crossover (point of intersection of the electron paths) between the components.

2.1.2 Bundling of the electron beam

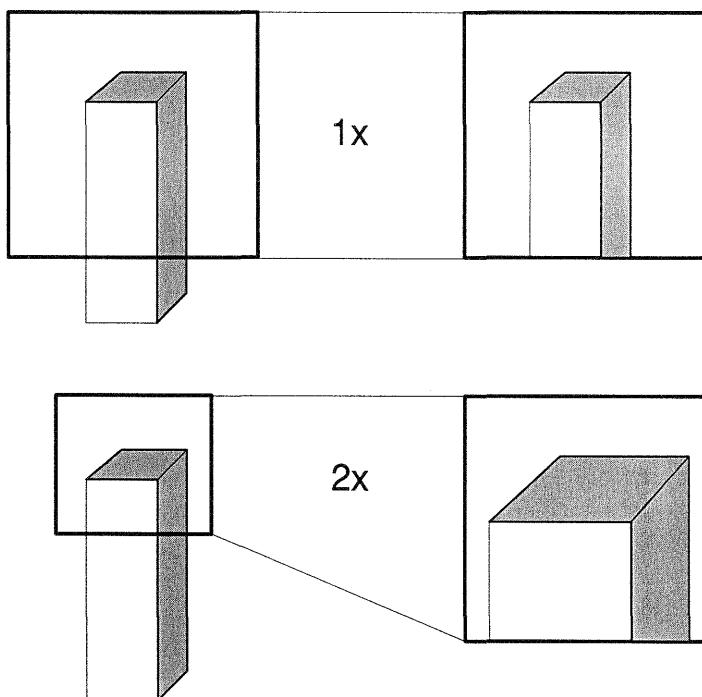
Through the borehole of the anode (7) the electron beam enters the two electromagnetic condenser lenses (8) and (9) which reduce the crossover.

2.1.3 Focusing the electron beam on the specimen

An electromagnetic objective lens (11) beneath the condenser lenses is aligned so that the focal spot after the subsequent condensers is further demagnified and imaged on the specimen surface (12).



2.1.4 Magnification principle



Deflection coils in the objective lens move the electron beam in a raster over the specimen.

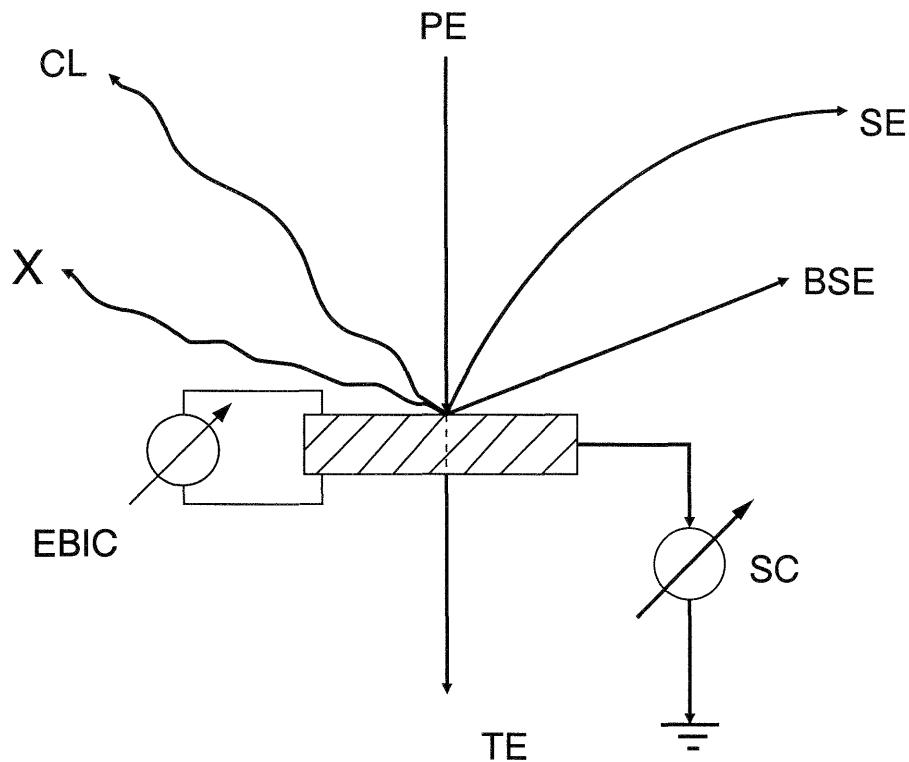
By digital control the specimen is scanned point by point.

The size of the scanning field on the specimen is a function of the magnification set from the console. The magnification defines the ratio of the size of the scanning field on the monitor to the size of the scanning field on the specimen.

The magnification is 1 if both scanning fields on the specimen and on the monitor are of equal size, as shown in the above schematic drawing. If the scanning field is only half this size, specimen details will be double the size in the image.

The smaller the scanning field on the specimen, the higher the magnification.

2.1.5 Signal release



The narrowly bundled electron beam (primary electron beam PE) releases different signals on the specimen surface:

SE : secondary electrons from the top layers of the specimen surface

BSE : backscattered electrons from a depth of up to $1 \mu\text{m}$

CL : cathodoluminescence of luminescent specimens

X : X-rays from areas of approx. $1 \mu\text{m}$

TE : transmitted electrons from thin specimens

SC : absorbed electrons which are grounded as current

EBIC : with semiconductor material the primary electron beam will separate the charge

This (incomplete) list of examples shows the wealth of information that is obtainable from a specimen with the scanning electron microscope and suitable detectors.

Secondary electrons are mainly used to image the specimen surface. The base instrument contains a detector for this imaging mode.

2.1.6 Resolution

It is mainly the spatial resolution that is of interest for scanning electron-microscopic imaging. Here, resolution is the capacity to distinguish two details as separate in the image.

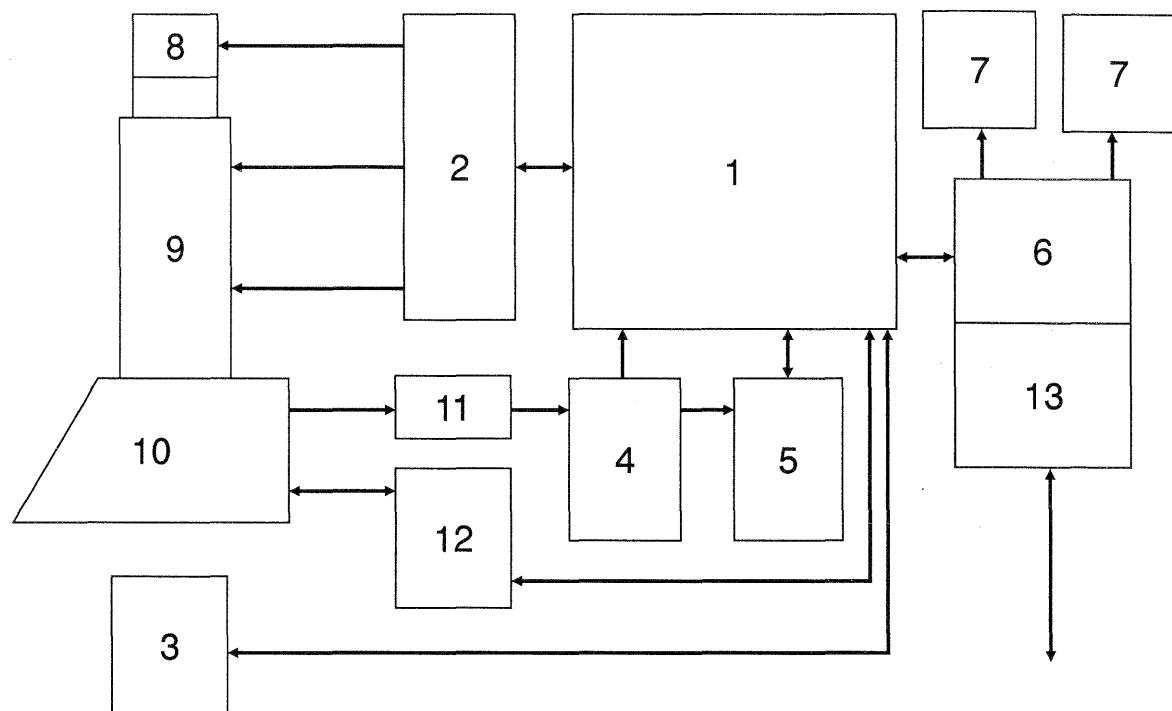
The limit of resolution is a function of the interaction of primary electron beam and specimen, which in turn is influenced by factors such as:

- Specimen type
- Accelerating voltage of the electron beam
- Beam current on the specimen
- Aperture size defining the beam aperture
- Alignment of beam axis
- Distance between specimen and objective lens(working distance)
- Correction of astigmatism
- Cleanliness of electron optical systems and clean vacuum

The design of the electron-optical system of the DSM 960 A assures that parameters which impair the resolution are kept as small as possible.

3. Design of instrument

3.1 Electronic components of the DSM 960 A



All control functions and image processing of the DSM 960 A Scanning Electron Microscope are fully digitized. This assures high flexibility, reliability and economy of operation.

(1) The system features a master central processing unit for:

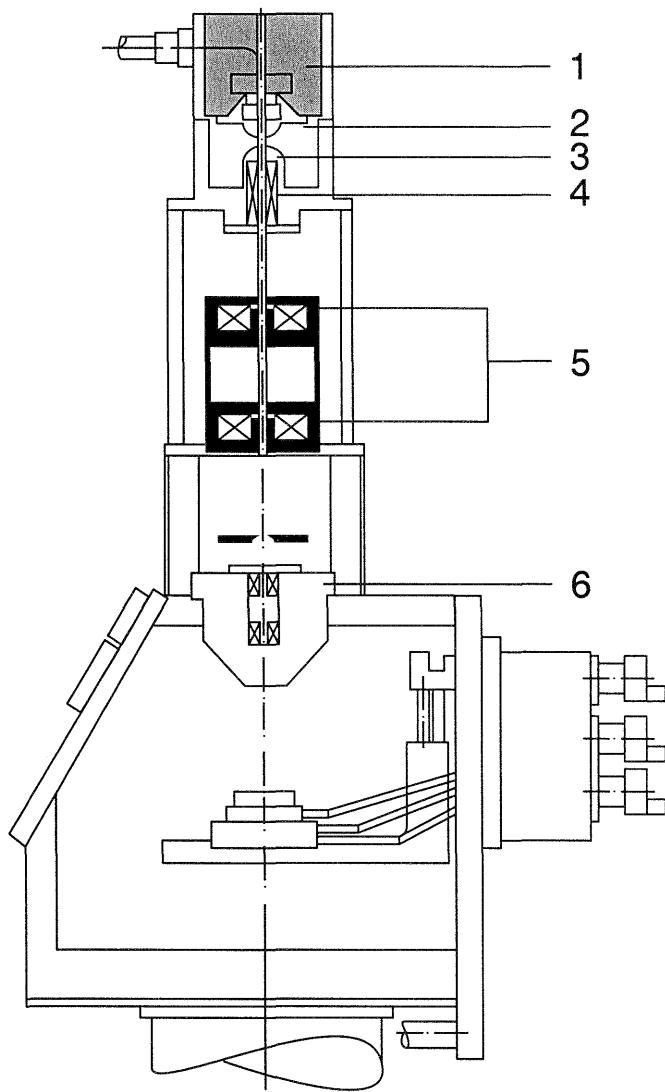
- (2) Control of electron optics
- (3) Control of vacuum system
- (4) Control of video system
- (5) Control of frame store
- (6) Control of operating console
- (7) Control of image monitor

- (8) Electron gun
- (9) Lenses and scanning coils
- (10) Specimen chamber
- (11) Video output
- (12) Stage control
- (13) Remote control

Link-up between the system and the user is the operating console from where the user operates the instrument.

The user need not familiarize himself with the operation of the controller; it is fully integrated in the system, which makes the DSM 960 A a highly ergonomic, easy-to-operate instrument.

3.2 Electron optics



3.2.1 Electron gun (1)

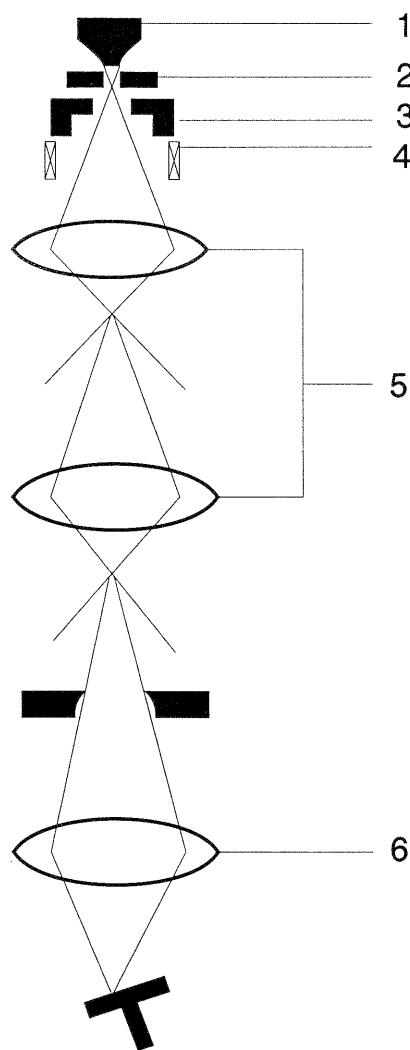
The precentered filament holder in the Wehnelt cylinder (2) is secured in the electron gun by a retaining ring.

3.2.2 Beam path

The anode (3) can be unscrewed for cleaning.

A vacuum tube isolates the condenser lenses from the vacuum chamber of the microscope. When the anode is unscrewed a cleaning tube in the vacuum tube can be pulled out for cleaning with the forceps (see 5.4). It also carries the spray electron apertures.

Beam alignment is made from the console with the electromagnetic beam alignment coils (4).



3.2.3 Condenser lenses

Beam current and size of the illuminating spot are adjusted with the condenser lenses (5). A condenser zoom system allows optimized probe size adjustment for each operating state of the DSM 960 A.

Digitally programmed condenser adjustment maintains constant image position of the crossover after the second condenser, and corrections of focus, astigmatism and aperture alignment are not necessary.

The lenses are precisely aligned in the factory, and prevent virtually any image shift when changing the beam current.

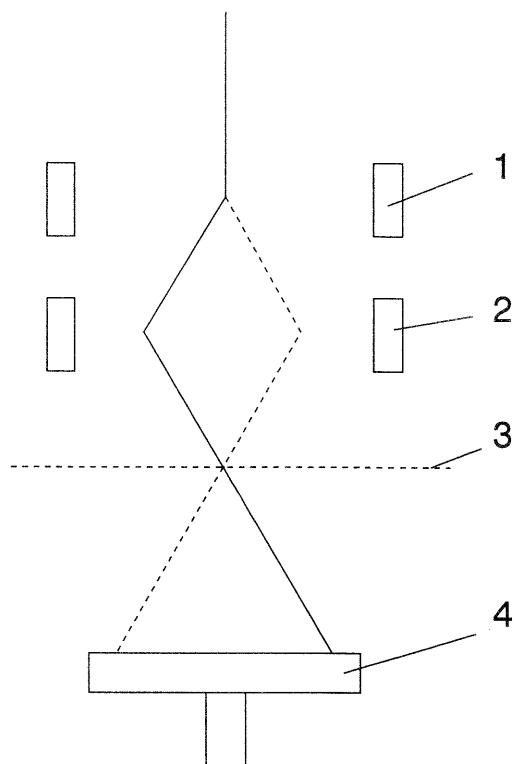
3.2.4 Objective lens

The objective lens (6) focuses the beam on the specimen. The lower part of the lens is conically shaped, permitting large, flat specimen to be tilted up to 45° at short working distance. In X-ray microanalysis this design provides for a 35° take-off angle without specimen tilt.

3.2.5 Deflection system

The electromagnetic deflection system is integrated in the objective lens and moves the beam in a raster over the specimen (4).

The deflection system consists of 2 sets of crossed saddle coils for deflection in X and Y. The saddle coils produce distortion-free images at lowest magnifications and permit large deflection angles. The upper set of coils (1) deflects the beam off the electron-optical axis. The lower set of coils (2) deflects it back on the axis at the point of intersection of axis and center of objective lens (3). This method allows low magnifications at short working distance.

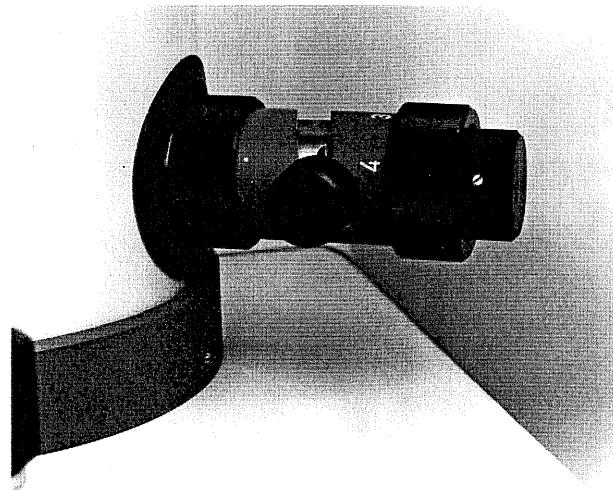


3.2.6 Stigmator

The 8-pole x-y stigmator incorporated in the deflection system compensates the stigmatic residual errors in the primary electron beam bundle.

3.2.7 Apertures

Four selectable apertures are accommodated in a holder above the objective lens. From the outside they are brought manually into the beam path and centered.



3.3 Specimen chamber

The specimen chamber has front access and 4 ports to mount additional detectors. Opening the door swings the specimen stage out of the chamber. Specimens max. 250mm in diameter can be accommodated in the chamber and specimens max. 150 mm in diameter scanned by the beam (Macrostage and rotation are necessary).

The detectors are mounted in the chamber so that they do not interfere with the specimen movement.

3.4 Eucentric specimen stage

Two different stages are available:

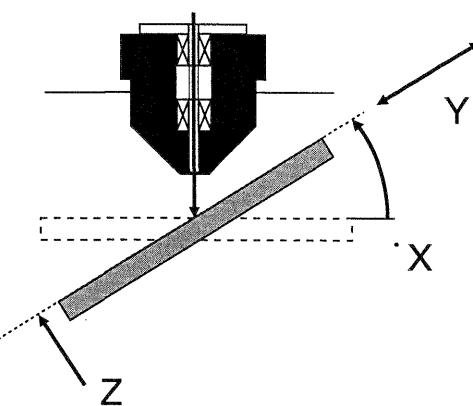
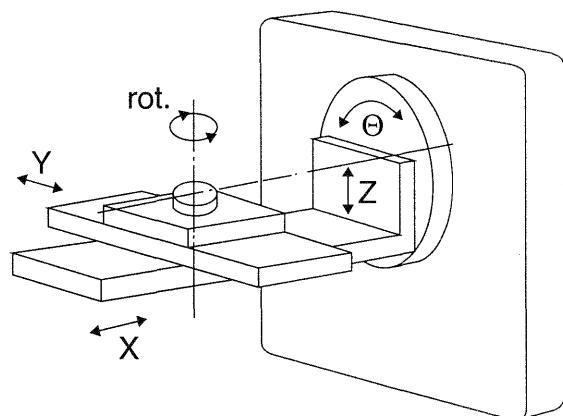
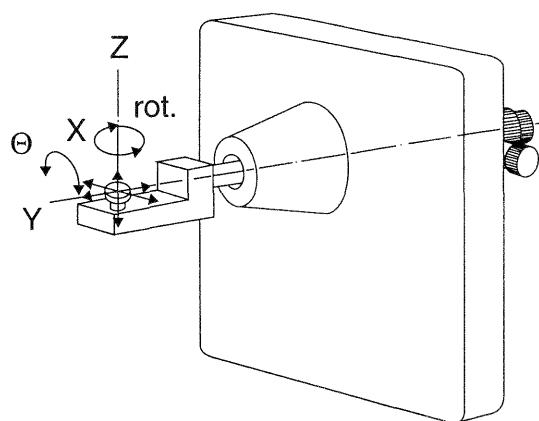
Standard stage and macrostage (see 1.4 specifications).

Both stages are high precision eucentric stages. The macrostage can be fitted with motor drives additionally.

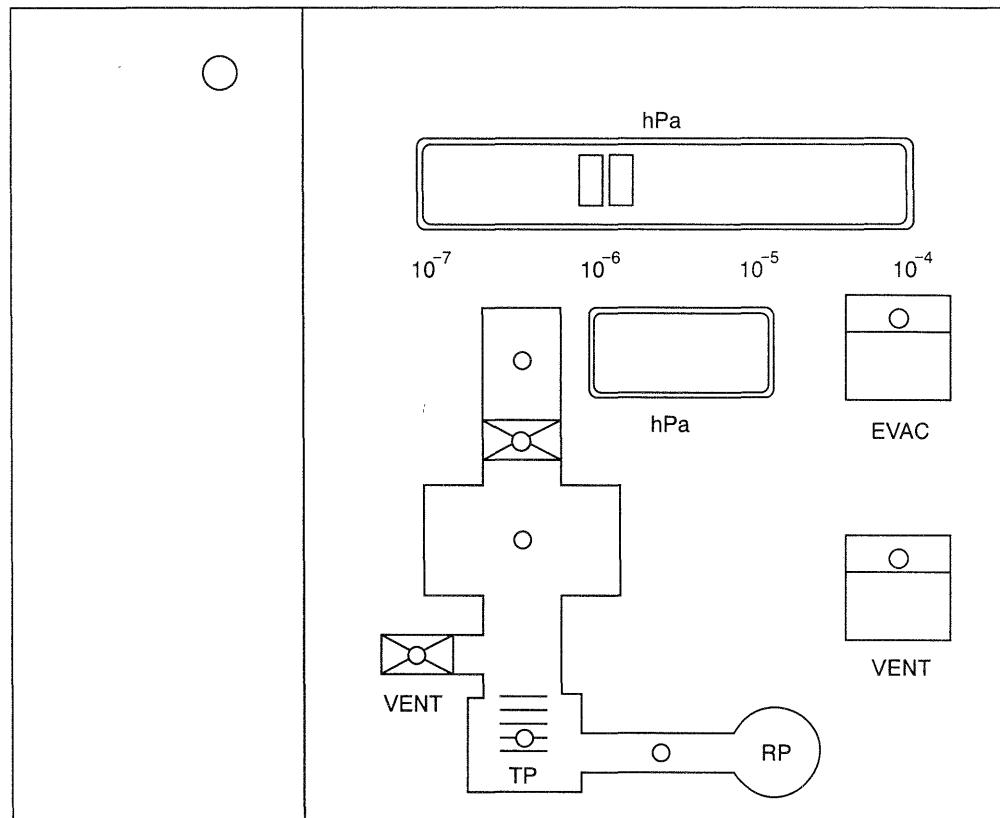
If the specimen surface is in the eucentric point where the tilt axis meets the beam axis, the focus is maintained if the specimen is tilted, rotated or moved in x or y.

The eucentric point is achieved at 15 mm working distance with the standard stage and at 47 mm working distance with the macro stage.

Different screw in spacers are used to adjust specimen height differences.



3.5 Vacuum system



Electron beams travel over long distances only in vacuum. The path for the electrons from the cathode to the specimen and from there to the detectors must, therefore, be in vacuum.

In a poor vacuum contamination products from residual gas deposit on the specimen and impair the image when electrons strike the specimen. This applies in particular to oil vapors from rotary and diffusion pumps.

The integral vacuum system of the DSM 960 A produces an absolutely hydrocarbon-free vacuum, but the user must take care to prevent contamination by the specimen itself when it is brought into the chamber.

The vacuum system consists of a turbomolecular pump and a rotary pump. The system has no isolating valves, which increases its reliability.

The vacuum system is microprocessor-controlled. Its actual state and the high vacuum are displayed. The system is automatically monitored. Any error is displayed by an error number. For the error codes see 5.9.

The chamber must be opened for specimen exchange, which is possible only at normal pressure. The instrument is flushed with dried nitrogen which keeps it under inert gas while open.

3.6 Shock absorbing system

Because of the high magnifications that can be realized in the scanning electron microscope, vibrations which affect column, chamber and stage must be eliminated.

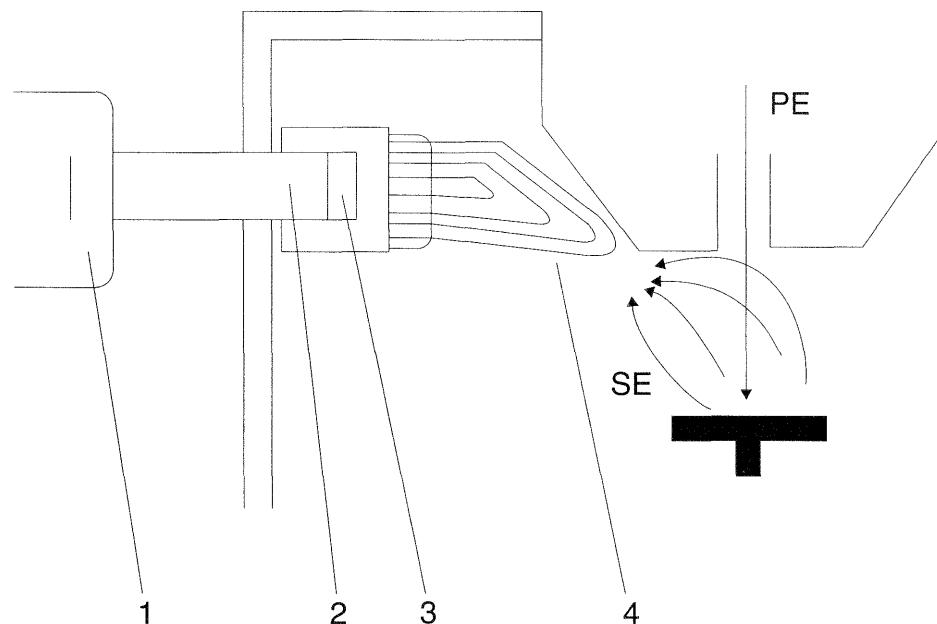
The system is mounted on shock absorbers which are inflated from the outside for levelling of column and chamber.

Alternative :

Autolevelling System

Sensors detect the level and control the level through a valve system automatically. Compressed air is required for this system.

3.7 Secondary electron detector



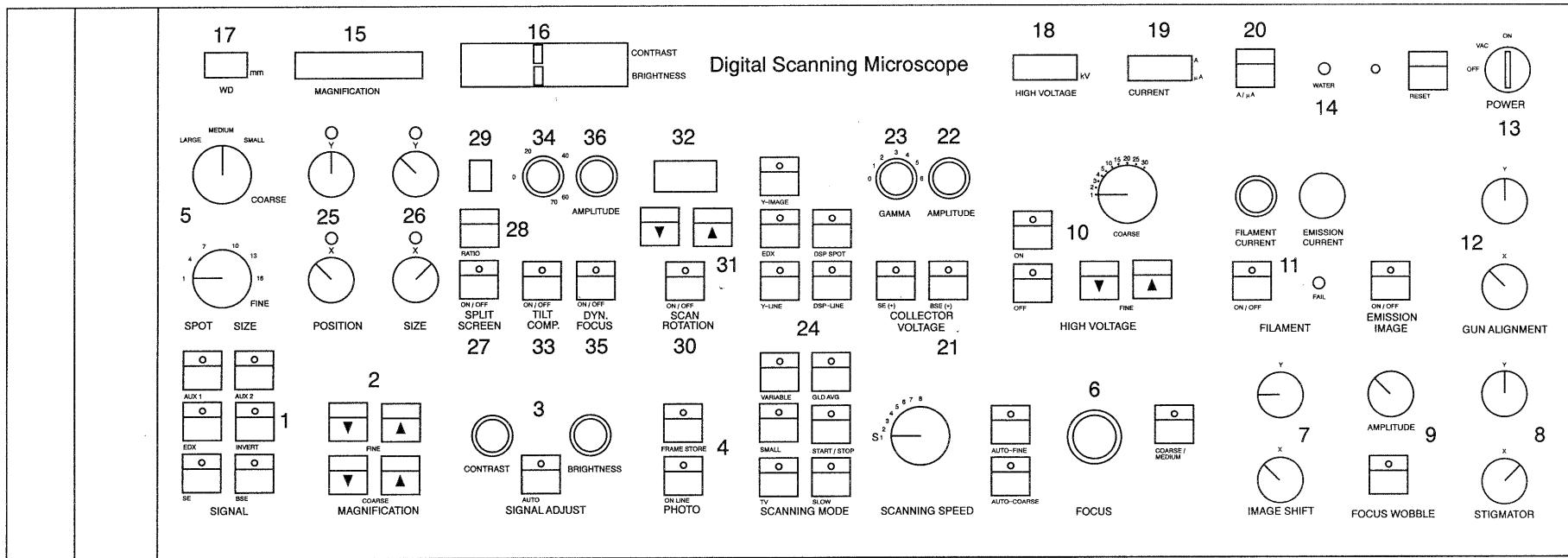
The secondary electron detector is mounted to the side of the chamber, with a scintillator (3) on a light guide (2) inside the chamber, with a grid-shaped collector in front (4).

The collector (4) is maintained at positive potential for the detection of secondary electrons, and produces about the specimen a collecting field for the secondary electrons which are induced to move towards the collector (4) and pass through the grid.

The subsequent scintillator (3) is biased to +10kV and accelerates the low-energy secondary electrons to a higher energy level. These strike the scintillator (3) where they generate photons which are guided out of the chamber and to a photomultiplier (1) by the light guide (2).

The photomultiplier (1) converts the light current by amplification again into electron current which presents the video signal on the output of the subsequent pre-amplifier.

If the collector is at negative potential, only backscattered electrons can strike the scintillator. A backscattered-electron image of the specimen surface is produced in this operating mode.



3.8 Console

The instrument is operated from the console. All controls are within easy reach of the seated user. The ergonomic design guarantees fatigue-free operation. The following controls are arranged directly above the table top:

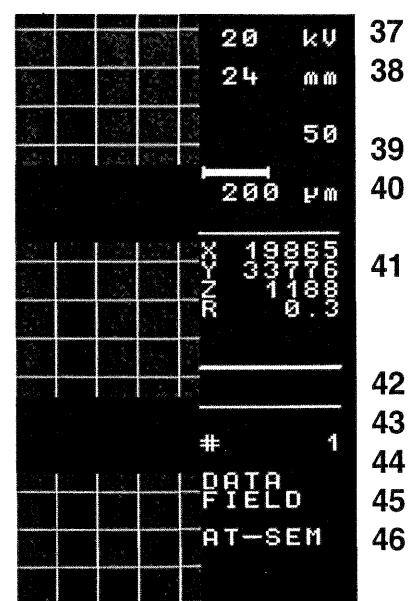
- | | |
|---|---|
| (1) Signal source selection | (21) Switch to change between secondary-electron to backscattered-electron mode of the SE detector |
| (2) Magnification setting | (22) Potentiometer for collector potential (0 - 400V) |
| (3) Brightness and contrast adjustment | (23) Gamma selector for non-linear contrast display |
| (4) Scanning modes and photography | (24) Keys for Y modulation for image and line, line and spot modes |
| (5) Spot size adjustment | |
| (6) Focus adjustment | |
| (7) Precision shift of image field | |
| (8) Stigmator setting | |
| (9) Focus wobbler for aperture alignment | |
| (10) High voltage setting | |
| (11) Filament heating | (25) Potentiometer for line and spot mark, variable raster, position of magnified field at dual magnification |
| (12) Beam centration and beam profil imaging for correct adjustment of the electron gun | (26) Potentiometer for size of variable reduced raster |
| (13) Main switch and reset key. | |
| (14) Water failure indication | |
| (15) Display of magnification | (27) Key for split screen |
| (16) Display of brightness and contrast levels | (28) Key for dual magnification |
| (17) Display of working distance | (29) Display of enlargement factor |
| (18) Display of high voltage | (30) Key for scan rotation |
| (19) Display of emission and heating currents of filament | (31) Direction keys for scan rotation |
| (20) Key to change between currents (19) | (32) Display of rotation angle |
| | (33) Key for tilt correction |
| | (34) Potentiometer for tilt correction |
| | (35) Key for dynamic focus correction |
| | (36) Potentiometer for dynamic focus correction |

The monitor screen is at the user's eye level in the middle of the console.

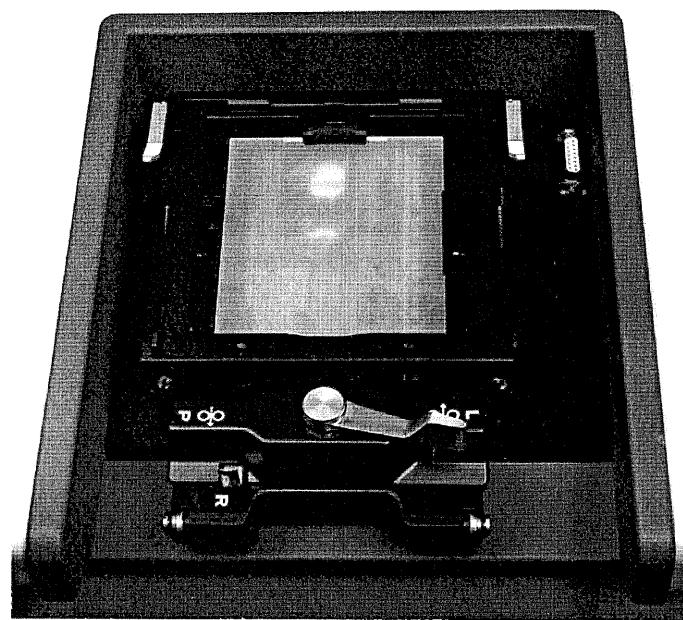
All relevant image data are displayed in the right margin:

- (37) High voltage
- (38) Working distance
- (39) Magnification
- (40) μ -bar with scale factor
- (41) Display field for motor stage coordinates
- (42) Communication field for motorized stage
- (43) Communication field for special functions
- (44) Photo number
- (45) 2 text lines
- (46) Logo

Attachments and accessories can be accommodated to the left in the console.



3.9 Photographic unit



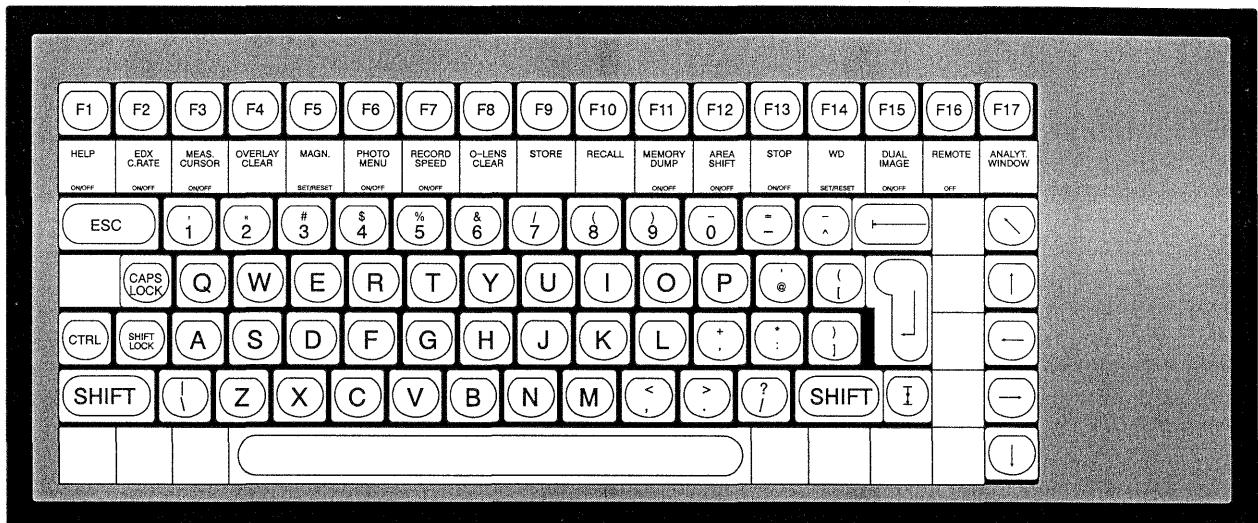
The photographic unit is accommodated to the right in the console, the instant film camera back sunk-mounted in the table plate.

Additional camera backs can also be mounted.

The photographic unit is automatically controlled; parameter change is from the keyboard.

The photographic unit is digitized and microprocessor-controlled; this ensures the necessary high stability of the system and reproducible results.

3.10 Keyboard



Special instrument functions are entered from the keyboard.

The user is guided by menufields:

- Help menu for explanation of key functions (F1)
- Input menu to control the photographic unit for different cameras and film types (F6)
- Menu to set the time for on-line photography (F7)
- Input of text in the data field
- Test images to calibrate the photographic unit for new film types
- Set up menu for X-ray microanalysis (F2)

4. Operating Instructions

4.1 Safety provisions

 Please note the safety provisions in paragraph 1.2 :
Electrical safety and protection against x-ray radiation.

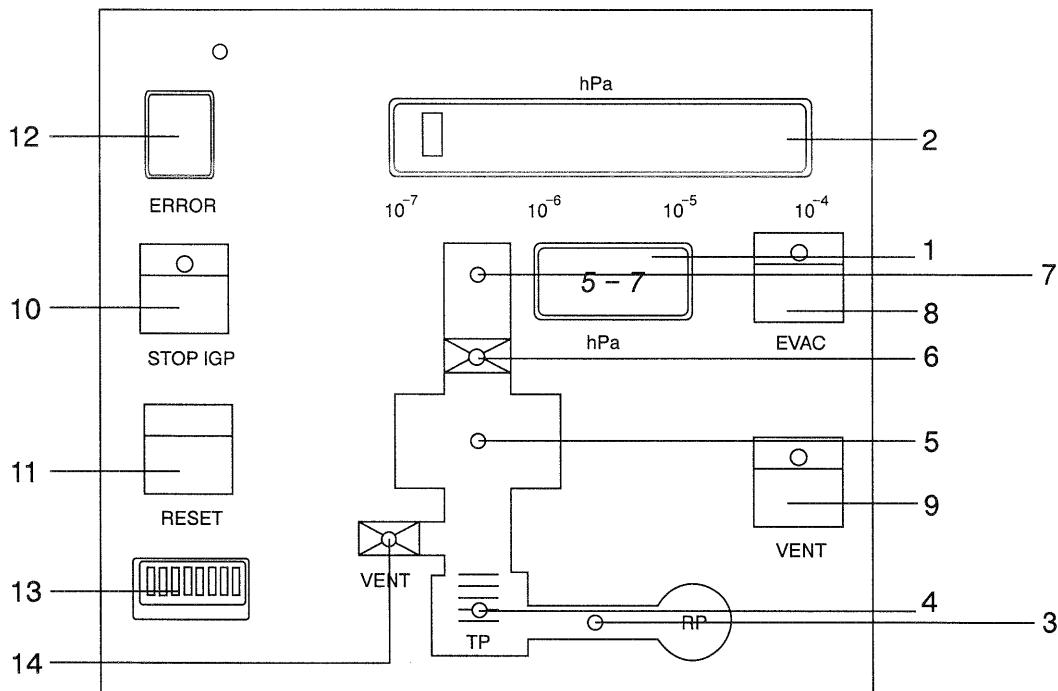
4.2 Instrument switch-ON/OFF

Please refer to chapter 5.12 if you have problems.

4.2.1 Preparations for use

- Switch on **main switch** (near door).
- Switch on **cooling water** (see 4.2.5).
- Open valve of **nitrogen** cylinder.

4.2.2 Vacuum system switch-on



- Turn **POWER VAC** key switch to vacuum position; the vacuum system starts.

- The rotary pump starts.

On the status display of the vacuum system:

- Turbopump starts
- Lamp (4) is on.
- Ventilating valve closed
- Lamp (14) out.
- VENT(9): red lamp on.

If the vacuum system is programmed for W-filament operation the red LED under the programming DIP-switches (13) is on.

The read out display for the gun pressure (1) and the ready lamp for good vacuum (7) and open column isolation valve (6) as well as the STOP IGP LED (10) are only operational if the differential pumping system is in use.

When the pre-vacuum level has been reached, the green LED (3) comes on and shortly after the chamber vacuum display (2) becomes active.

When the operating vacuum has been reached the green LED (5) comes on and also the ready lamp in the high voltage key.

4.2.3 Electronic system switch-on

POWER ON:

the electronic system is on and the instrument set to standardized start conditions:

- SE electron detector as signal source
- Magnification as set in the RESET menu
- Automatic brightness and contrast adjustment
- Spot size on switch position
- Focus as WD-setting in the RESET menu
- High voltage on switch position
- High voltage and heating current off
- TV scan

4.2.4 Instrument switch-off

Total switch-off

POWER OFF:

the entire (electronic and vacuum) system is switched off.

The chamber is ventilated in part with dried nitrogen before the instrument is completely turned off.

- Close valve of **nitrogen** cylinder.
- Switch off **cooling water** (see 4.2.5).
- Switch off **main switch** (near door).

Switch off electronic system alone

If the vacuum system is to remain operative, set key switch **POWER** to **VAC**.

This switches off the electronic system while the vacuum system remains operative.



It is necessary to maintain cooling-water flow. The nitrogen valve should be open to allow partial ventilation of the instrument in case of power or water failure.



4.2.5 Automatic cooling-water circuit

The cooling water can be switched on and off, controlled by the vacuum system by a control current terminal on the DSM 960 A.



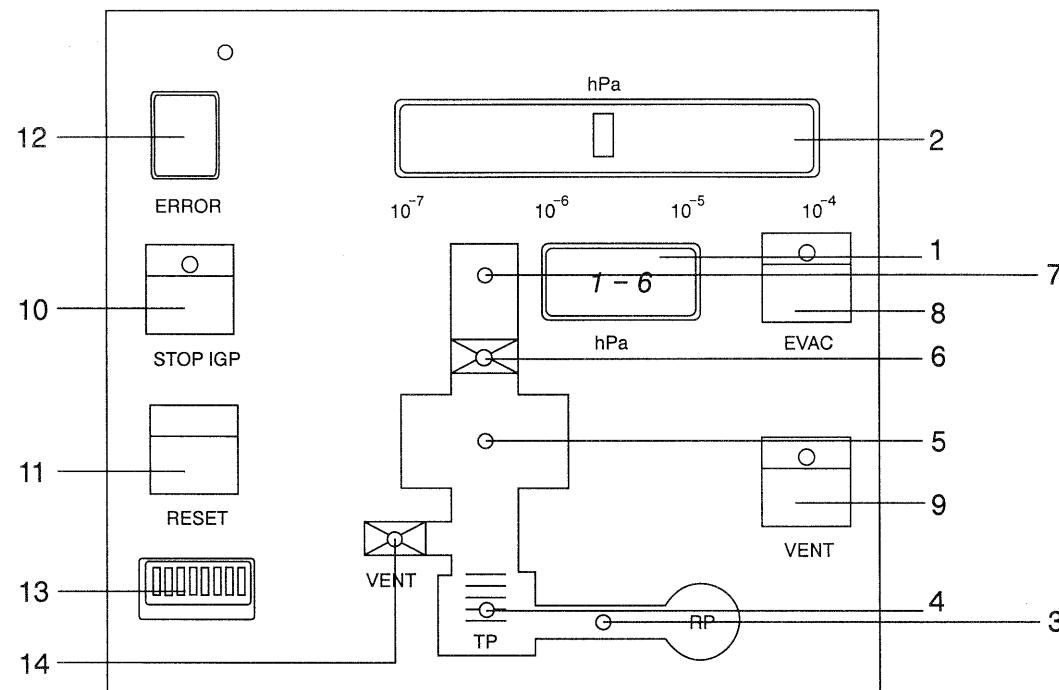
A magnetic valve for water supply can be controlled by this terminal, but not a complete closed-loop cooling system with the supply of the necessary electrical power on the DSM 960 A.

But it is possible to switch a control relay in the closed-loop cooling system, which will then switch the cooling system on and off.

4.3 Specimen insertion

The vacuum in the specimen chamber must be eliminated by ventilation with dried nitrogen if you want to load a specimen. Thereby a controlled atmosphere is established in the chamber during specimen exchange, and adsorption of water on the surfaces in chamber and column prevented.

4.3.1 Ventilating the chamber

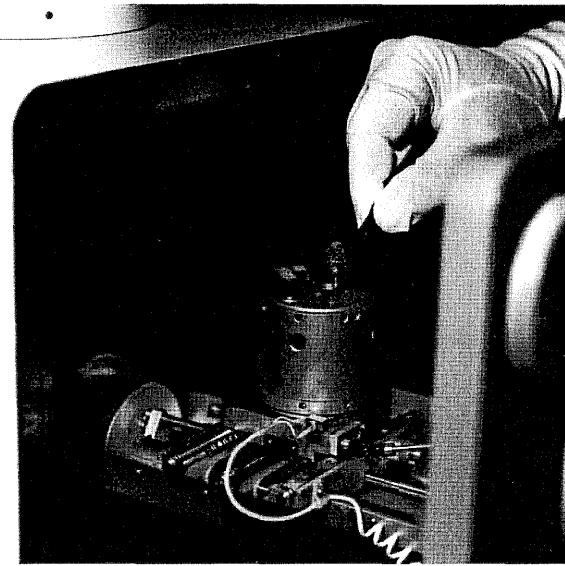


- Press key VENT (9); lamp out
 - Rotary pump stops, lamp (3) out
 - Turbopump stops (lamp (4) out)
 - Vacuum measurement display (2) off
 - Vacuum display (5) out
 - Ventilating valve opens ((14) to red)

Ventilation is audible: the intake of nitrogen makes a hissing noise.

When ambient pressure is attained in the chamber the door is slightly lifted and then may be opened. Raise lever and swing out door.

4.3.2 Mounting the specimen



The specimen is mounted on 12.5 mm dia. stubs. Apply the forceps to a groove in the stub and insert it in the stage.

Different heights of the specimens are compensated by exchanging inserts.

They are screwed in and tightened moderately.



Caution!

Parts in vacuum shall only be handled with clean cotton gloves to prevent contamination from entering the vacuum.

4.3.3 Evacuating the chamber

- Swing in the door. Check that the specimen does not touch the pole piece.

The guide wheel must engage the groove at the lower end of the chamber next to the door latch. The latch snaps in when the door is closed.

- Press EVAC (8) key.

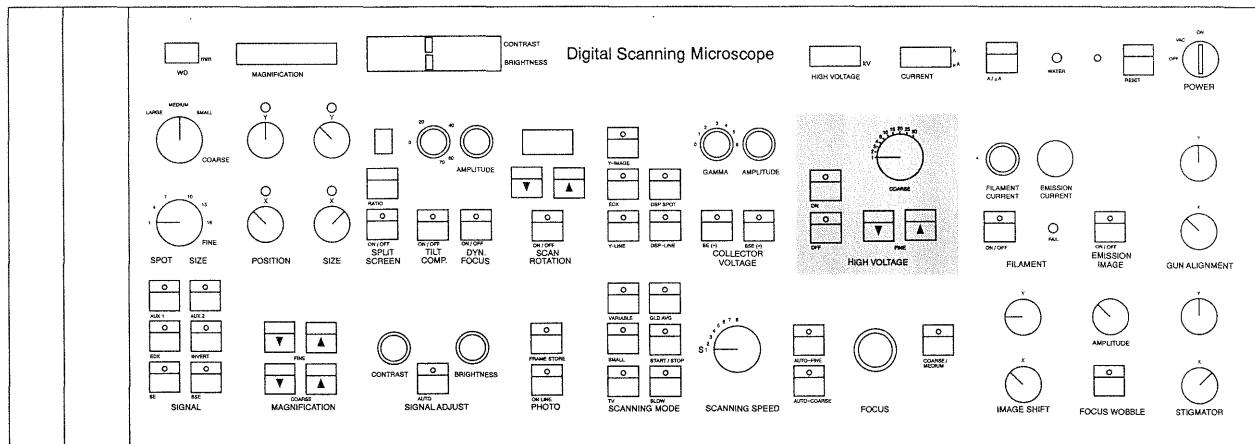
Pumping starts as described under 4.2.2.

The operating vacuum of 4×10^{-5} hPa is attained after approx. 200s: the instrument is ready for operation.

The "ready" condition is displayed by the lamp of high-vacuum display (5) (green) and the green lamp (2) in the key **HIGH VOLTAGE OFF** (1), which is on.

4.4 Switch-on and alignment of electron beam

4.4.1 High voltage



Remark:

The high voltage can be switched on only if the operating vacuum has been reached, e.g. the green LED (2) in key OFF (1) is on.

If the chamber is ventilated, the high voltage is automatically switched off (safety interlock).

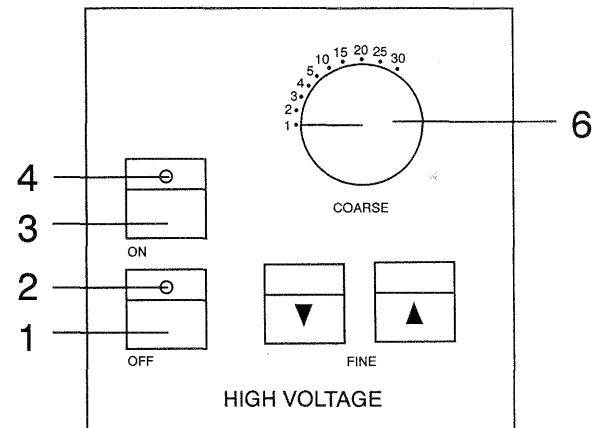
HIGH VOLTAGE ON

- Switch high voltage on (3).
- The red lamp (4) in the key is on, the green (2) is out.

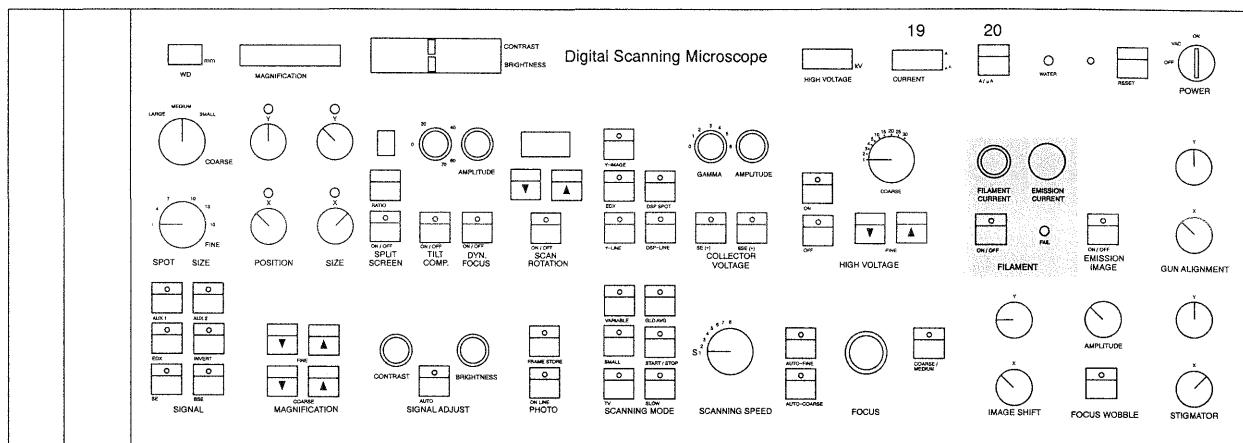
HIGH VOLTAGE COARSE

- Preselect high voltage with rotary switch (6).

See 4.10 for the use of different high voltages.



4.4.2 Filament heating, emission current



Special note:

The heating current can be activated only with attained operating vacuum. The filament heating is automatically switched off (safety interlock) when the chamber is ventilated.

FILAMENT ON

- Switch-on of filament heating current (1).

The lamp FAIL (3) is out during heating of the filament.

If a burnt-out filament requires replacement, the red lamp in FAIL (3) will be on.

Heating current display

The heating current which passes through the filament is displayed at (19) on the front panel if heating current display (A lights at the bottom of the display) was activated with key (20).

The heating current is an indication of the filament condition. At saturation a new filament requires approx. 3.7 A heating current at 30 kV and 80 μ A emission current. The heating current drops to approx. 2.8 A before burnout.

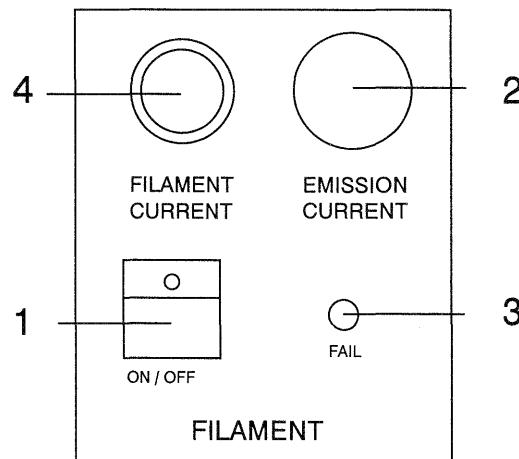
These values vary for different instruments and filaments.

The heating current is adjusted with potentiometer **FILAMENT CURRENT** (4). To do this the knob must be pressed down to activate the clutch.

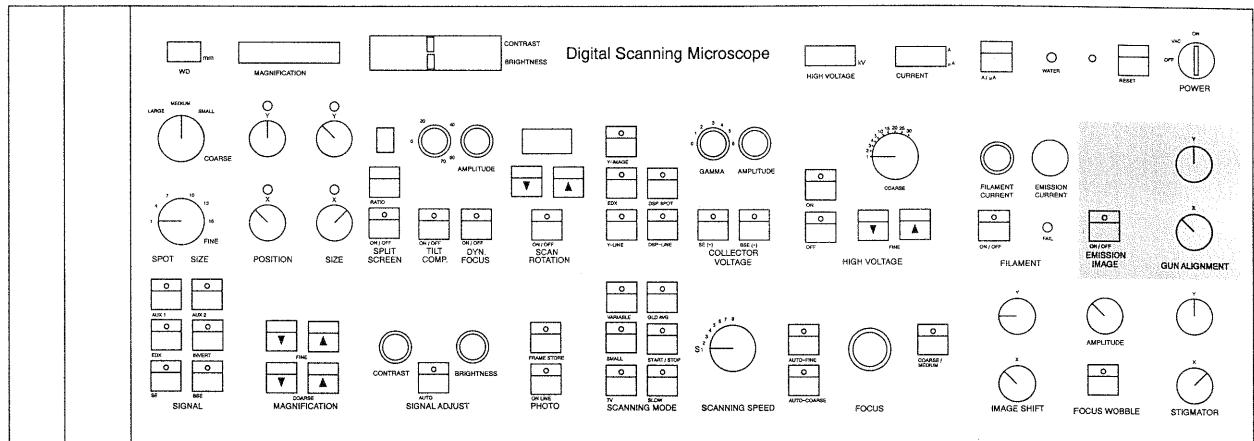
Without pressing down the knob it may be turned without action preventing inadvertend change of the filament current.

Emission current

The emission is adjusted with the 3-turn potentiometer **EMISSION CURRENT** (2) and displayed at (19) on the front panel, if emission current display (μ A lights on top of the display) was activated with key (20). Approx. 80 μ A are recommended for normal operation.



4.4.3 Emission saturation



The emission current will increase considerably at first when the **FILAMENT CURRENT** (4) control is slowly turned up; it then ceases to increase, an indication that the heating is at saturation. In the beam cross section this point is attained at the transition from the hollow to the full beam.

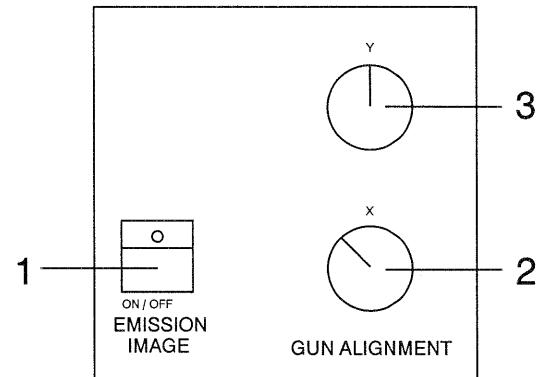
The beam profile imaging mode (BEAM PROFILE) is provided in the DSM 960 A for the purpose.

Press **EMISSION IMAGE** (1):

the beam profile is displayed on the screen. If the filament heating is too low the profile will correspond to the upper image. (# 2)

Now turn **FILAMENT CURRENT** (4) clockwise until it corresponds to the lower image (# 3) the full beam is adjusted.

The filament is saturated.



Caution:

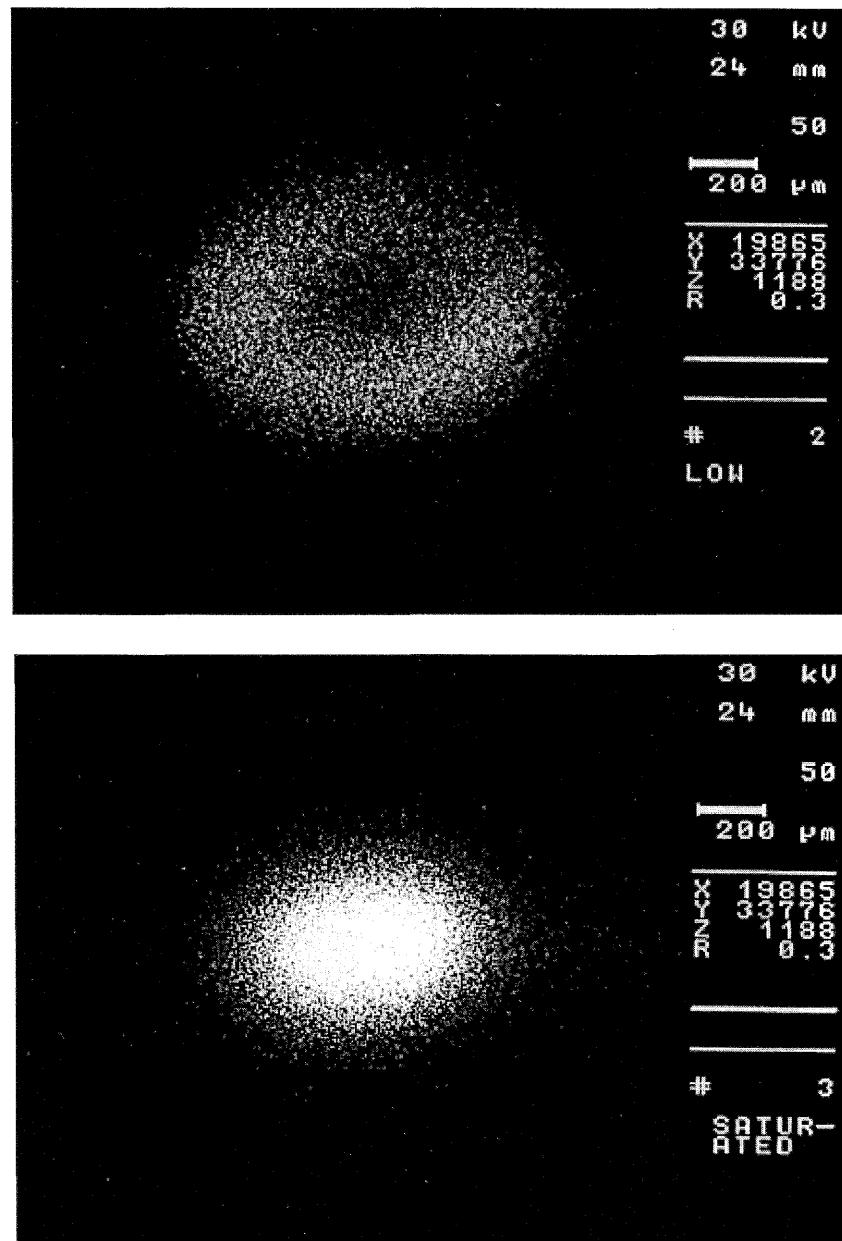
heating beyond the point for saturation decreases filament life without serving any useful purpose.

When the operating conditions vary, saturation may be attained at different heating currents:



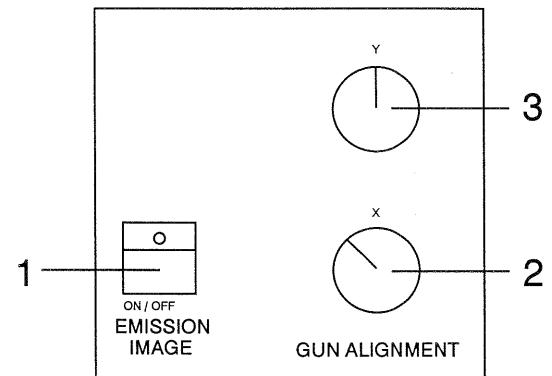
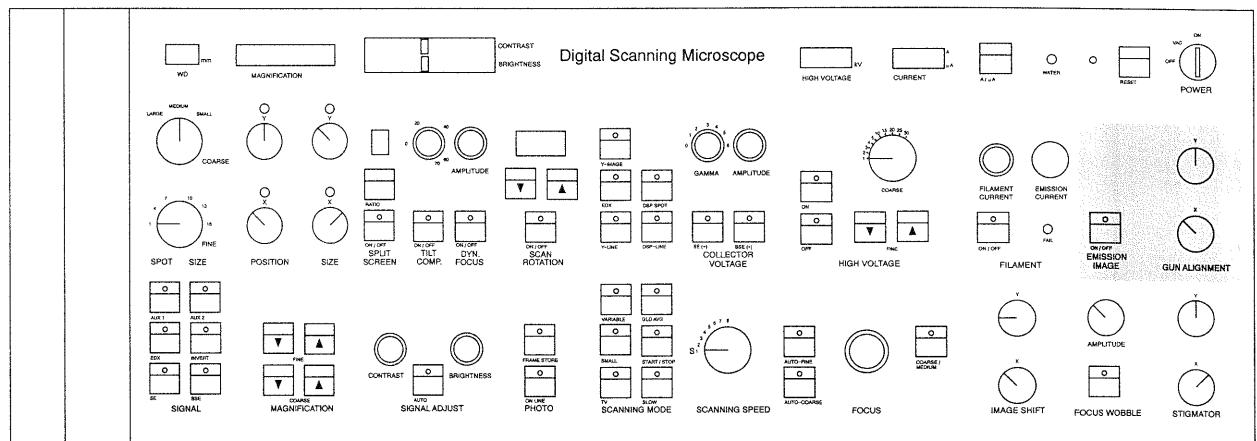
The higher the emission current the more heating current is required for saturation.

For operating a LaB₆ filament please refer to the manual provided with this accessory.



4.4.4 Beam centration

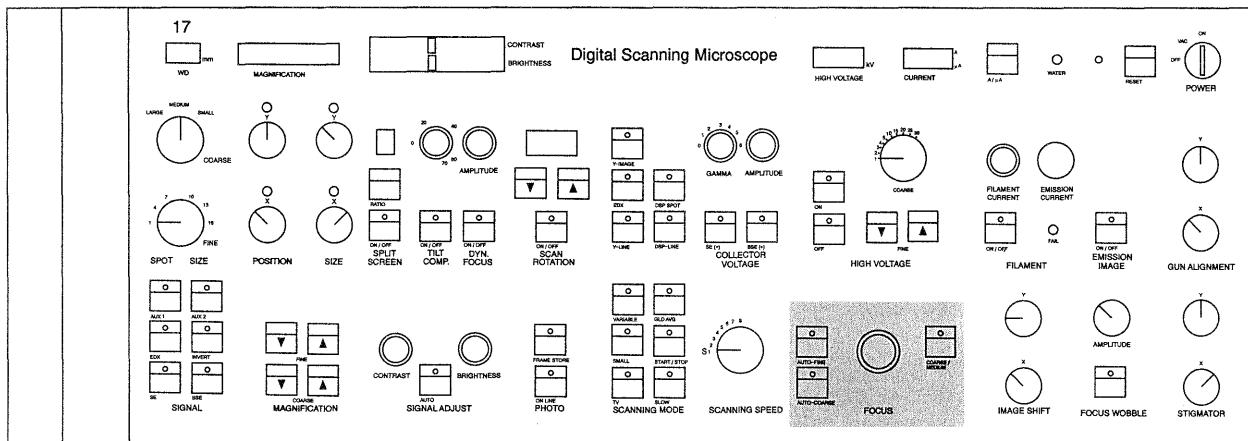
- Coarsely center the beam profile image in the image with **GUN ALIGNMENT X** (2) and **Y** (3).
- Escape from this mode by pressing **EMISSION IMAGE** (1) again.
- Switch off automatic brightness and contrast adjustment and adjust maximum image brightness with **GUN ALIGNMENT X** (2) and **Y** (3) (fine centration). The aperture must be centered (see 4.6).



4.4.5 Beam switch-off

- Pushing the key **FILAMENT ON/OFF** switches off the heating current, the yellow lamp goes out.
- Pushing the key **HIGH VOLTAGE OFF** switches off the high voltage, the red lamp in **HIGH VOLTAGE ON** goes out; ready condition is indicated by the green lamp in **HIGH VOLTAGE OFF**.

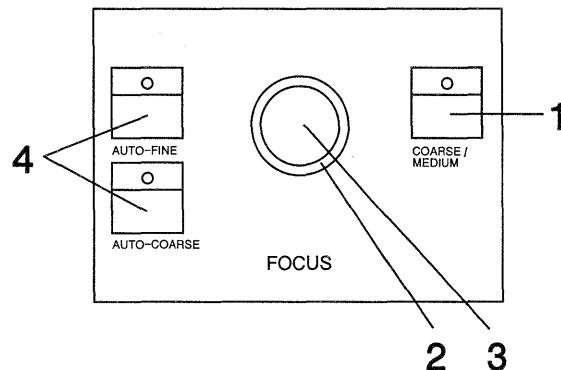
4.5 Focus adjustment



The focus is correctly adjusted if the image on the screen is sharp. There are two possibilities of focus adjustment.

4.5.1 Focusing on the specimen

- Press key **FOCUS COARSE MEDIUM** (1); the yellow lamp should be out (**COARSE** position).
- Focus coarsely with the outer knob (2).
- If the focus range is found, press key **FOCUS COARSE MEDIUM** (1), the yellow lamp should be on (**MEDIUM** position).
- Now focus with outer knob (2).
- Fine focusing should be made with the inner knob (3) at very high magnifications. The fine focusing range extends over approx. 3 click-stop positions of the medium focusing range.
- When the focus is adjusted the working distance (distance between specimen surface in focus and lower edge of objective lens) is displayed on WD display on the front panel (17) and in the data field.



4.5.2 Moving the specimen to the focus plane

For a specific working distance, adjust at first the desired working distance with **FOCUS COARSE** according to the working distance display (17). Now move the specimen to the focus plane with the z-drive of the stage.

- ☞ Remember that the displayed values for the working distance are given in increments of whole millimeters (integers).

4.5.3 Autofocus

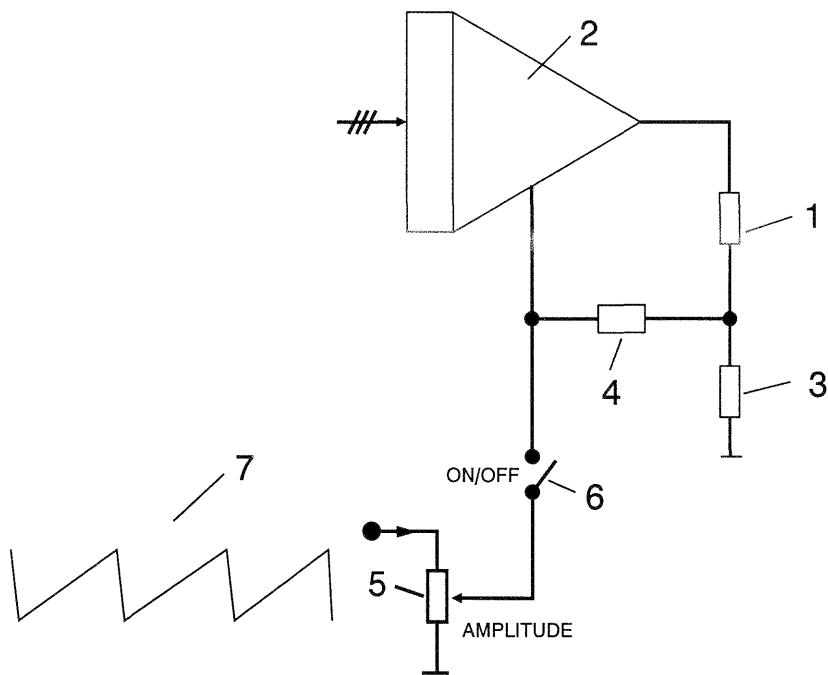
These keys (4) are operative only with built-in autofocus accessory. Focusing is then automatically made on the specimen surface when the key **AUTO** is pressed.

4.5.4 Dynamic Focus

The high depth of focus of the scanning electron microscope is due to the projection of the scanning electron beam on the specimen under a small aperture angle of only a few milli radians.

It is possible that the depth-of-focus range is exceeded if a flat specimen is excessively tilted. The edges of the image are then defocused, a fact which becomes especially obvious in high resolution on-line photography where more pixels or lines are scanned.

If the plane is made to coincide with the specimen surface in the scan pattern of the beam the defocusing at the edges of the image is avoided. With the dynamic focus this is made automatically if the focus is correctly adjusted. The image will then be in focus even at high tilt angles.



Circuit-diagram

The position of the electron-beam focal plane relative to the specimen is determined by the current flowing through the objective lens (1) of the DSM 960 A electron-optical column.

The current is supplied by a digitally controlled power amplifier (2). The digital values change with the focusing. The current is measured by the resistor (3) and relayed to the power amplifier (2) by the feedback resistor (4), which produces a stable control loop for the lens current.

The input variable of the Dynamic Focus is the saw tooth of the image deflection (7). A variable value is fed to the power amplifier (2) with potentiometer (5) via ON-OFF switch (6); the power amplifier then supplies a saw tooth current to the lens for corresponding modulation of the focal length.

If the image deflection starts on top of the image, the lens current is reduced and the focal plane adjusted to a longer working distance; the current is higher at the lower edge of the image and the working distance correspondingly shorter.

Limitations

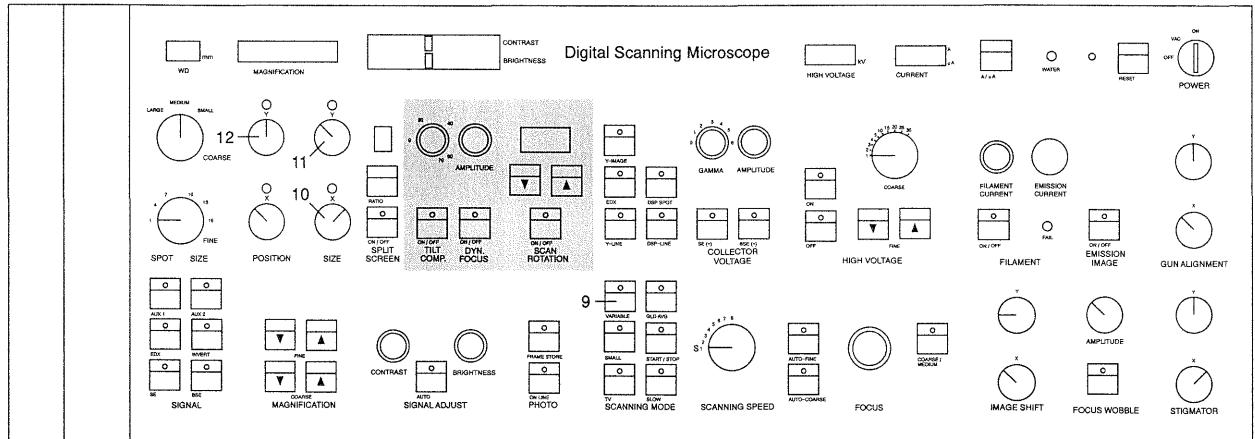
a) TV scan

The Dynamic Focus cannot be used in TV image mode because of the high induction of the objective lens. Only with scanning times above the position of S1 a sharp upper edge of the image is ensured (after frame fly back).

b) Specimen tilt

The specimen must be tilted so that the tilt axis is horizontal in the image field; the adjustment can be made with Scan Rotation.

Switch-ON/OFF



- The Dynamic Focus is switched on by the key **DYNAMIC FOCUS ON/OFF** (2); the yellow LED in the key lights. Pushing the key again switches the Dynamic Focus off; the LED goes out.

Adjusting the strength

- The amount of dynamic focus is adjusted by the potentiometer **AMPLITUDE** (1). The amount increases when the potentiometer is turned clockwise; it is zero when the potentiometer is turned fully anticlockwise.

Aligning the image field

The Dynamic Focus is effective in the direction of the image (vertically). Adjust the tilt of the specimen surface so that the upper edge of the image lies at the specimen area with the longest working distance, and the lower edge at the area with the shortest distance.

- Push **SCAN ROTATION ON/OFF** (8) and turn the image until the above condition is fulfilled (keys 7 and 6).

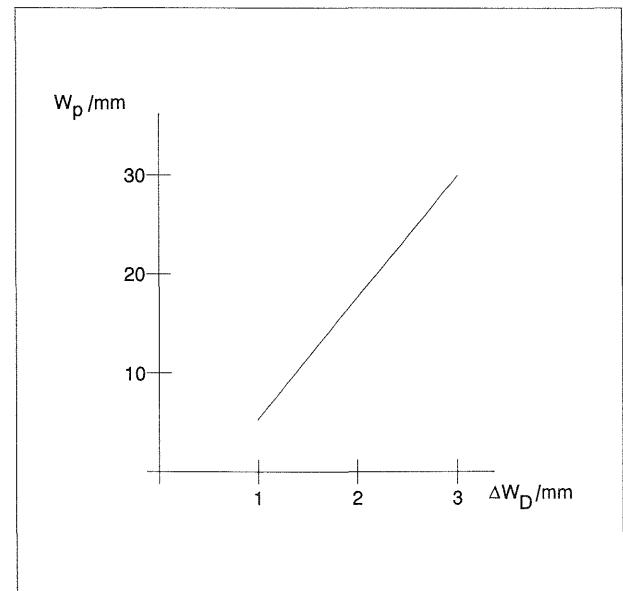
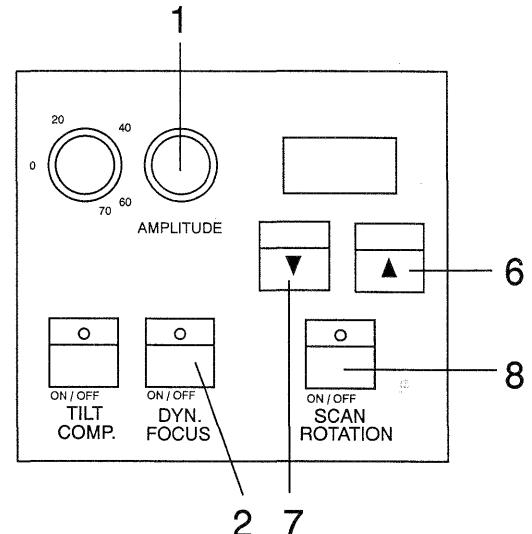
Adjusting range

The approximate adjusting range with potentiometer **AMPLITUDE** (1) turned fully clockwise is shown in the opposite diagram.

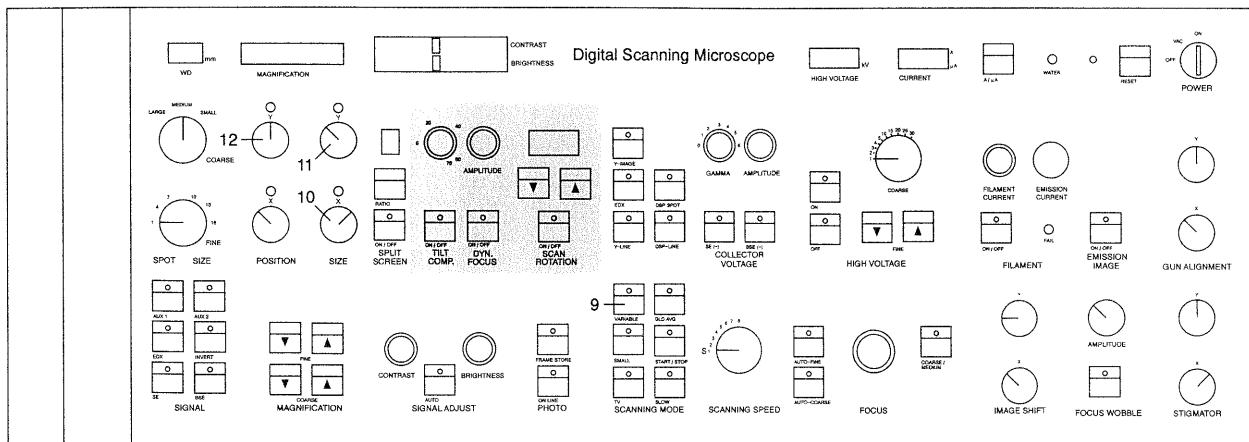
Example:

Max. 1 mm focus correction can be achieved with 5 mm working distance.
For 30 mm the correction will be 3 mm.

The Dynamic Focus is not high-voltage compensated. Because of the higher lens power the adjusting ranges will be larger with low high voltages.



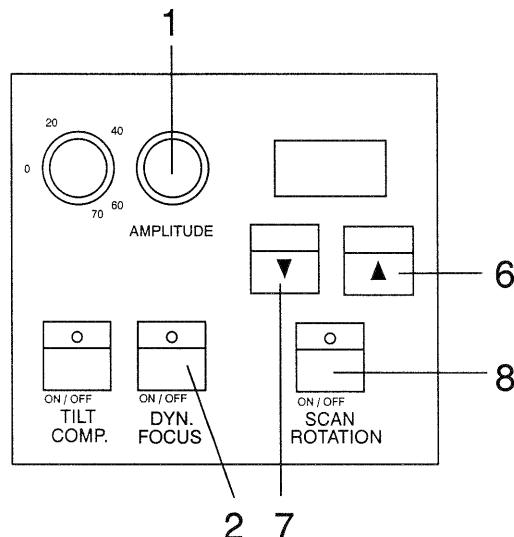
Aligning the Dynamic Focus



There are two ways to align the Dynamic Focus:

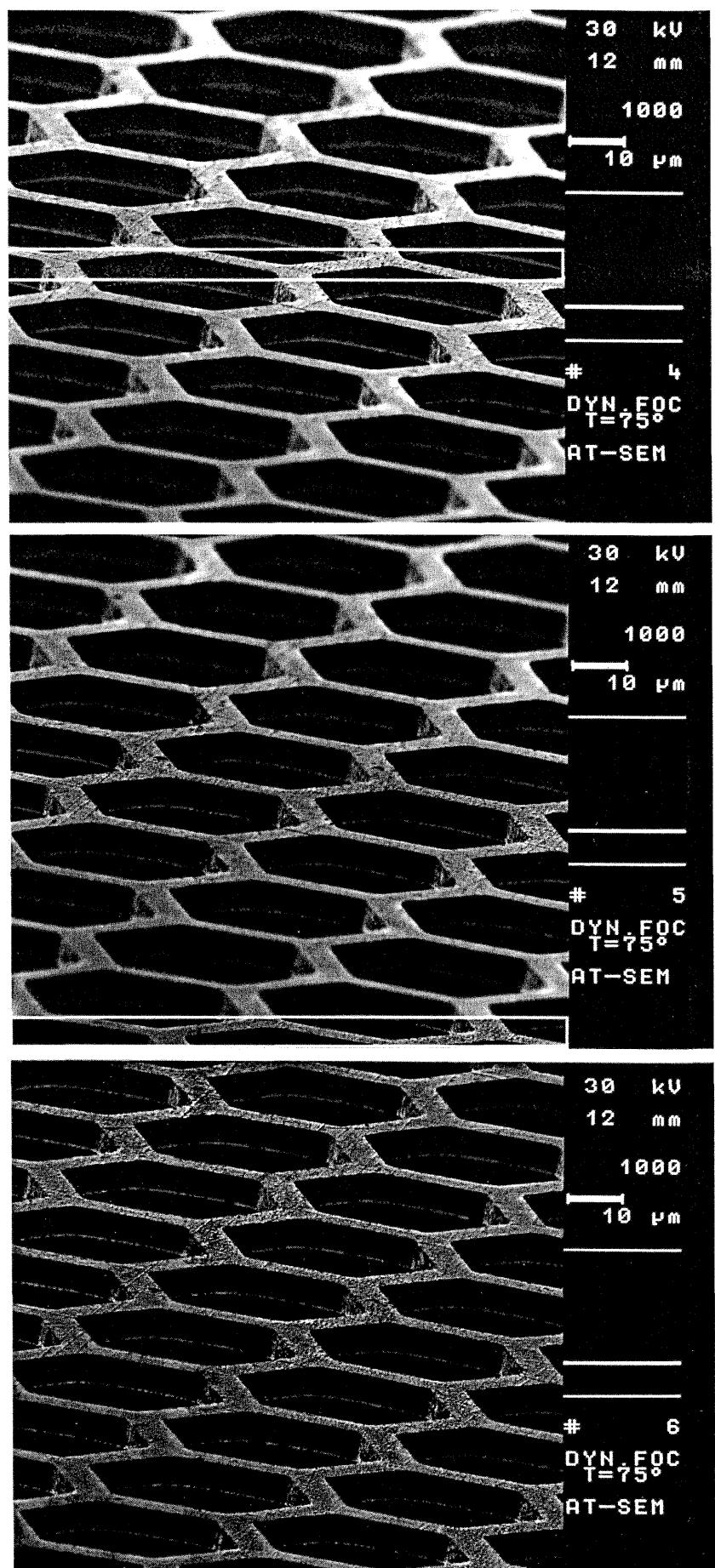
Direct alignment

- Switch on Dynamic Focus with **ON/OFF** (2) and turn **AMPLITUDE** (1) fully anticlockwise.
 - Choose the scanning time **SLOW S1** or longer and focus on the image center.
 - Choose the scanning time **SLOW S2** or longer. Focus on the upper or lower edge of the image with **AMPLITUDE** (1); do not use normal focus any more.

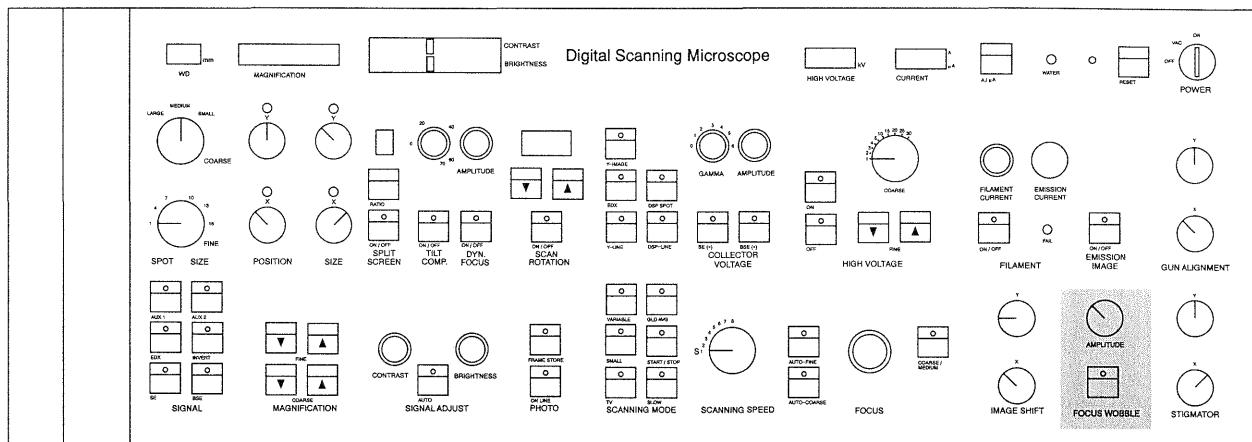


Alignment with Variable Raster

- Switch on Dynamic Focus with **ON/OFF** (2) and turn **AMPLITUDE** (1) fully anticlockwise. Choose the scanning time **SLOW S1** or longer.
 - Switch on reduced variable raster **RED. VAR.** (9), set **SIZE X** (10) to maximum and **SIZE Y** (11) to minimum so that a narrow band is produced.
 - Center this band in the image **POS Y** (12), and focus within the band with **FOCUS**.
 - Move the band to the upper or lower edge of the image **POS Y** (12), and focus with **AMPLITUDE** (1).
 - When the variable reduced raster is switched off the entire specimen surface as from **SLOW S2** will be in focus.



4.6 Aperture alignment

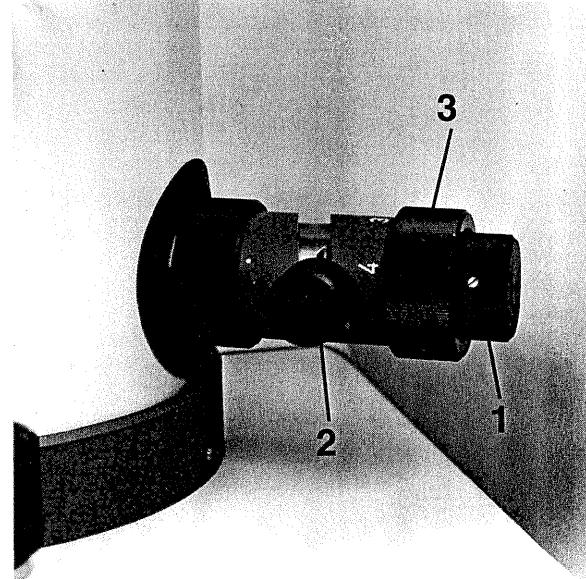
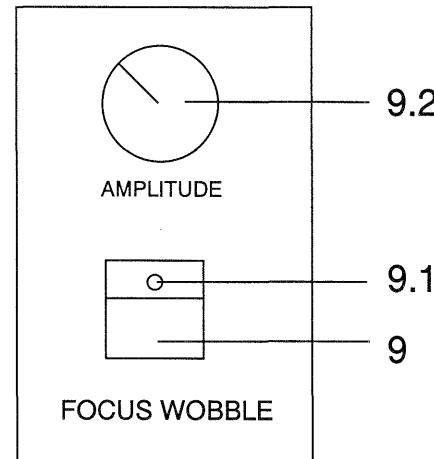


If the image is laterally displaced during focus adjustment, the aperture centration may be incorrect.

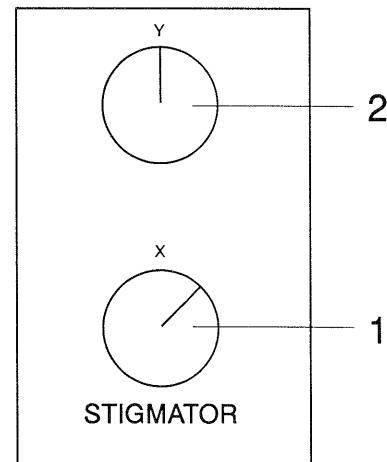
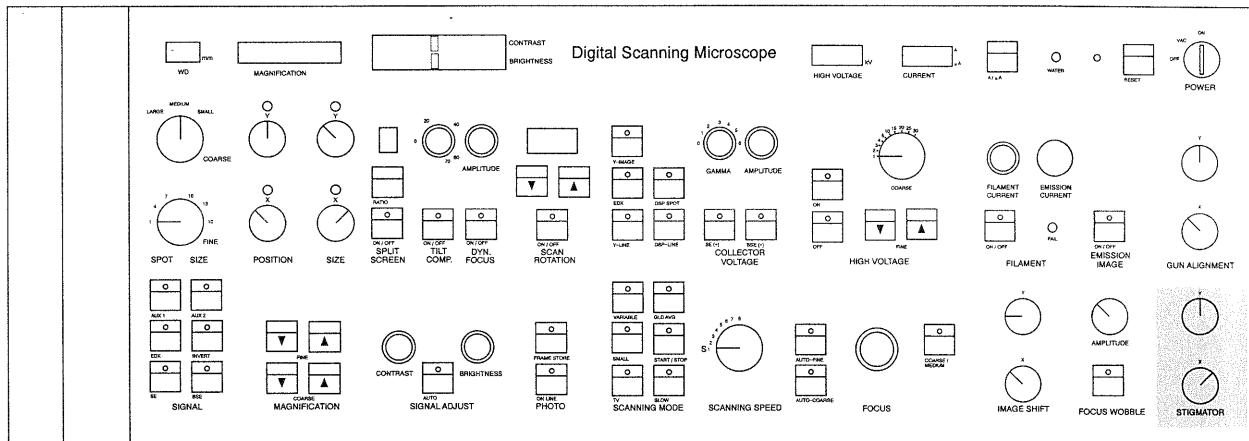
- For aperture alignment switch to TV at medium magnification, activate key **FOCUS WOBBLE ON/OFF** (9) (yellow lamp 9.1 on), and turn up **AMPLITUDE** (9.2).

The image wobbles.

- ☐ Compensate lateral wobble with drive (1), vertical wobble with drive (2) of the aperture selector.
 - ☐ Either of the 4 apertures may be selected with drive (3). The alignment is correct if the image is stationary and passes only through the focus.



4.7 Correction of astigmatism



- Before you correct astigmatism, check the centration of aperture and electron beam alignment (for aperture centration see 4.6 electron-beam alignment 4.4.4).

Misalignment may simulate astigmatism.

- Use a magnification which is high enough to clearly display astigmatism (normally 10 000x) and a small, circular or rectangular feature in the image.

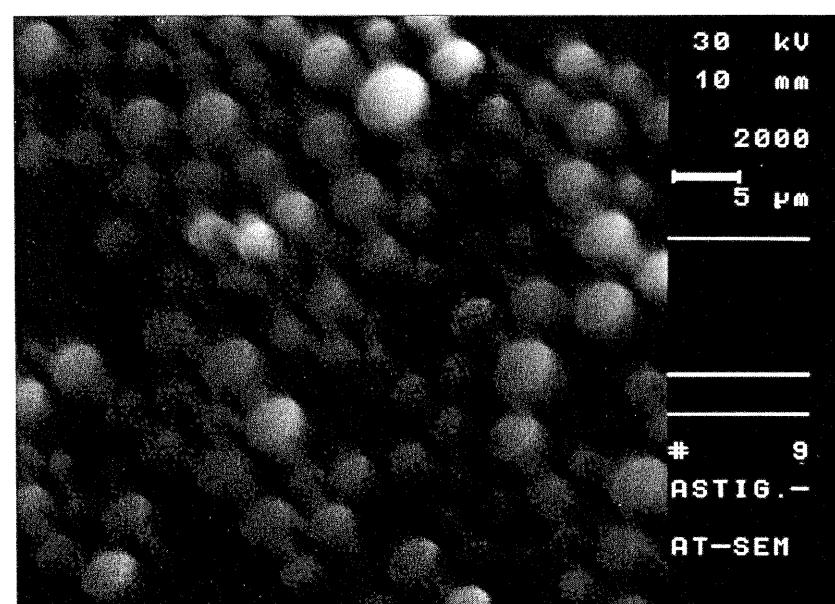
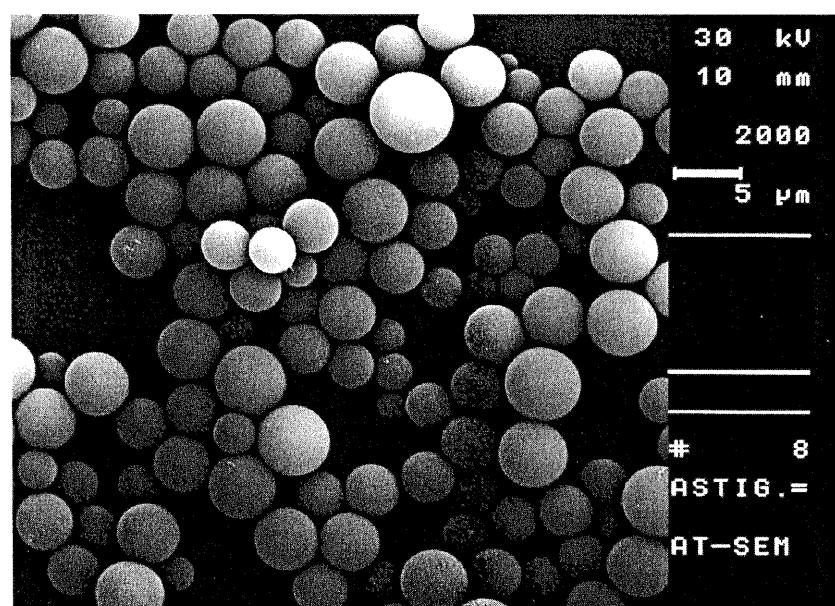
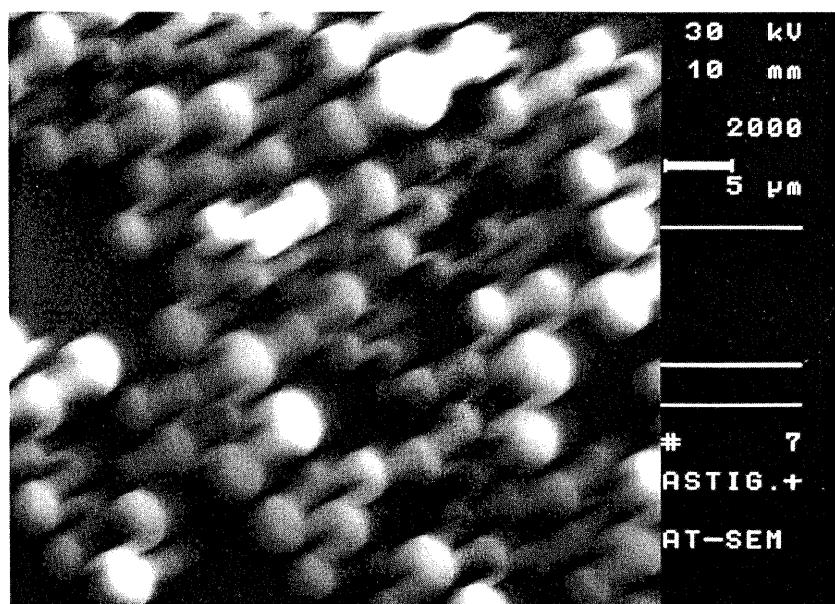
Through-focusing will lead from one privileged focus direction (image #7) to another (image #9).

- Set **FOCUS FINE** to the middle between the two.
- Now optimize the sharpness of the image with the potentiometers **STIGMATOR X** (1) and **STIGMATOR Y** (2).

Through-focus again; no privileged directions should occur. Otherwise repeat the procedure.



High astigmatism indicates contaminated apertures or a contaminated cleaning tube. For cleaning see Section 5.2.



4.8 Specimen screening

The most frequently used operating mode is the secondary-electron mode applied to screen a specimen for surface structures. The quality of the results is influenced by a number of opposite parameters. The user has to find a compromise which best suits his purposes. Some parameters are listed in the table below.

The symbol + means that both parameters agree, - that they oppose, and 0 that they do not influence each other.

Resolution		+	+	-	-	-	-
Magnification	+		0	-	0	-	-
High voltage	+	0		+	0	0	-
Beam current	-	-	+		+	+	0
Aperture size	-	0	0	+		+	0
Fast scanningspeeds	-	-	0	+	+		0
Working distance	-	-	-	0	0	0	
	Reso-lution	Magnifi-cation	High voltage	Beam current	Apertu-re size	Fast scan-ning speeds	Wor-king distance

The table displays, for example, that high resolution, high magnification and high voltage agree, but not with high beam current, larger aperture, fast scanning speed and long working distance. The opposite also applies, i.e. no high resolution is required at low magnifications, so that the beam current may be increased.

4.8.1 Working at low magnifications (up to approx. 1000x)

- SCANNING MODE TV
- RESOLUTION MED 7
- APERTURE 2 - 3

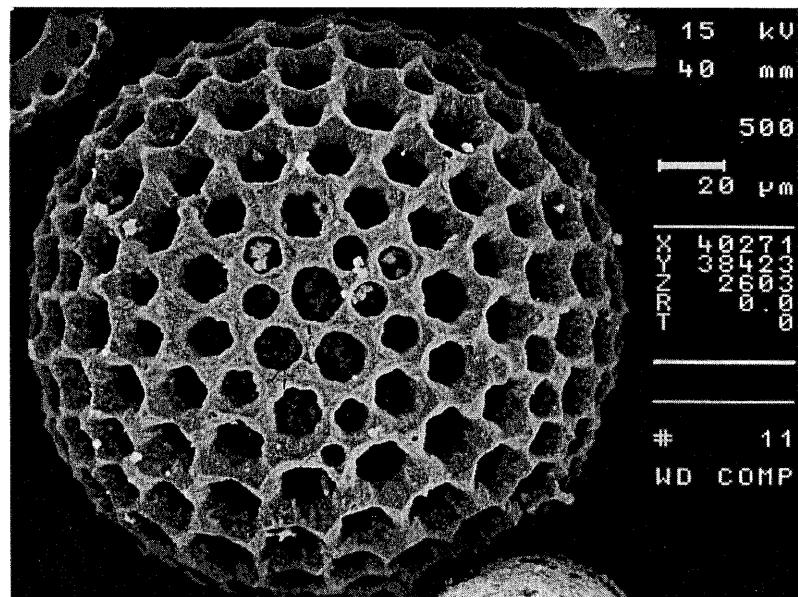
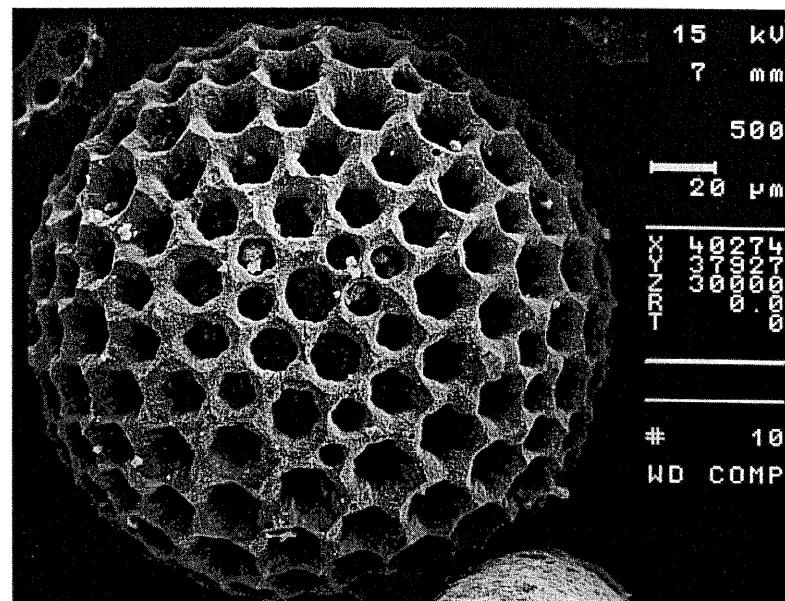
The above-mentioned values guarantee an almost noise-free TV image.

SPOT SIZE may be increased (higher beam current on the specimen), but only if the specimen is not damaged by the beam.

Adjust the magnification coarsely with **MAGNIFICATION COARSE** (steps 1, 2, 5 10, etc.) by activating the corresponding keys. The steps are automatically continued if the key is held down.

The magnification may be adjusted in small percentage steps (zoom) with **MAGNIFICATION FINE**, e.g. to adjust an image section.

The magnification is independent of the working distance. If you focus on the specimen at different working distances, the magnification is maintained, which means that the scanned specimen surface remains the same (see opposite pictures at WD 7 mm and WD 40 mm).



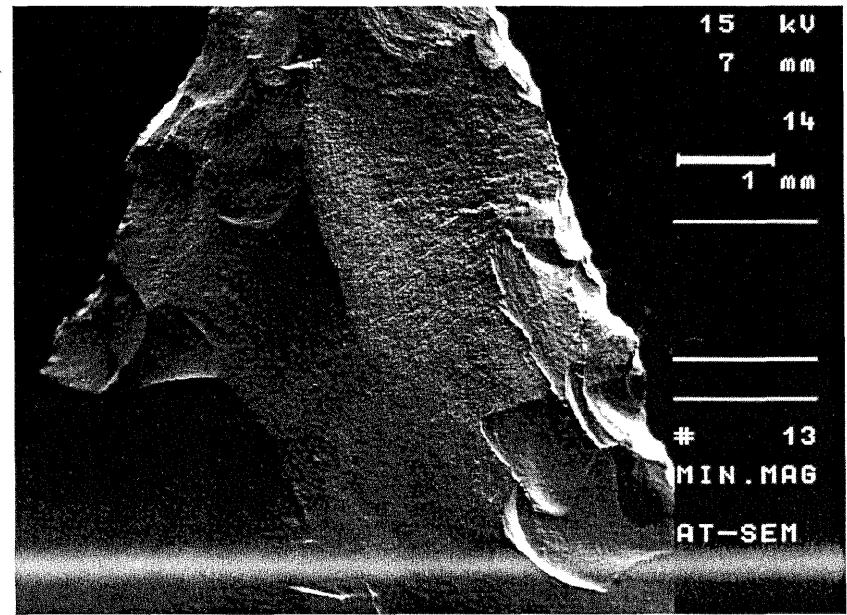
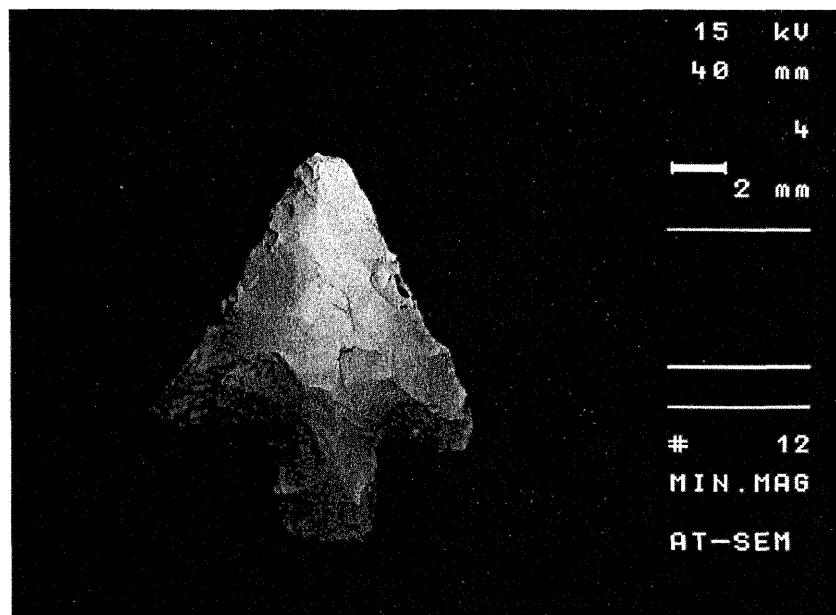
4.8.2 Lowest magnifications

The lowest attainable magnifications depend on the working distance.

The lowest magnification is 15times at 7mm working distance and 4times at 40mm working distance.

Low-power magnifications are suitable to quickly survey a specimen.

- Low-power magnifications are adjusted by setting **MAGNIFICATION COARSE** to the lowest value and from there use **MAGNIFICATION FINE** all the way down.



4.8.3 Working at medium magnifications (1 kx to 10 kx)

In this magnification range it gets important to correctly adjust with **APERTURE** and **SPOT SIZE LARGE/SMALL** to arrive at satisfactory sharpness of the image.

- Select appropriate aperture at the aperture changer and center it.

At high voltages below 5 kV the resolution limit may be already reached. Then proceed as described under the following paragraph 4.8.4.

4.8.4 Working at high magnifications (as from 10 kx)

In this magnification range one comes very near the performance limits of the DSM 960 A; all adjustments must be made most carefully, especially:

- Centration of the filament in the Wehnelt aperture (5.3.2)
- Filament saturation (4.4.3)
- Beam alignment (4.4.4)
- Aperture selection and alignment (4.6)
- Correction of astigmatism (4.7)

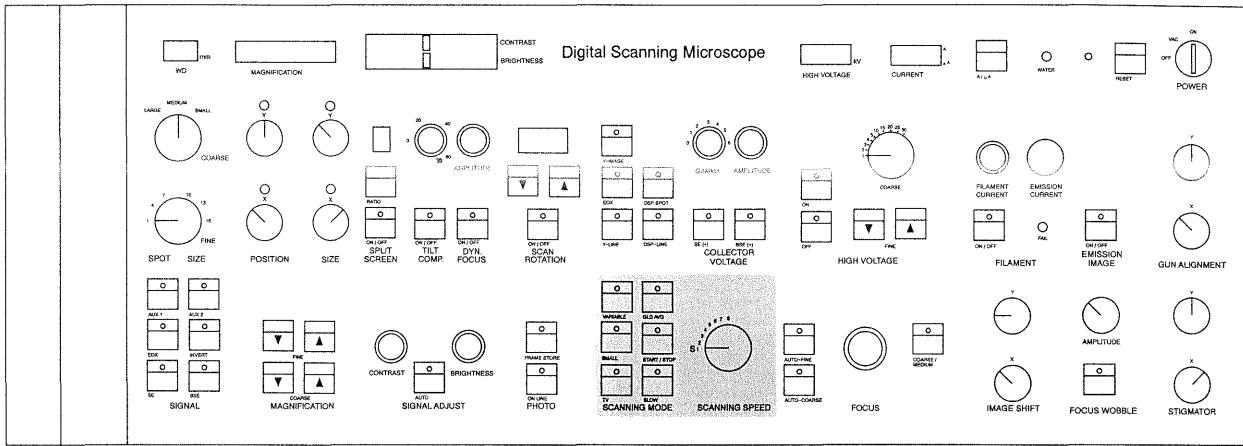
- Set **SPOT SIZE** range to **SMALL**.

The lower the beam current, the lower the signal and the higher the noise; longer scanning times must be used.

You should also use short working distances, which reduce the influence of external magnetic strayfields and produce a smaller effective spot because of the higher demagnification of the crossover in the column.

4.9 Use of different scanning modes

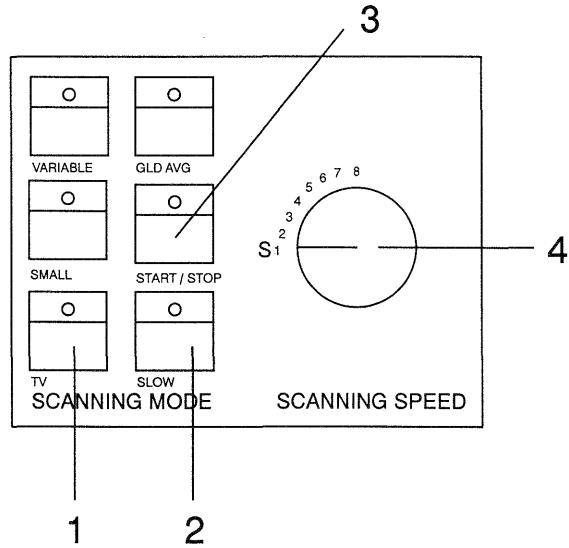
4.9.1 Standard TV (SCANNING MODE TV) (1)



TV mode is applicable if the magnifications permit the generation of a high, noiseless signal with **SPOT SIZE LARGE**.

Specimens can be quickly adjusted and screened because the TV image instantly follows the mechanical movement of the specimen (25 frames/s).

This mode is applied also to image dynamic processes, e.g. for aperture alignment with the focus wobbler.



4.9.2 Slow scan mode (SLOW) (2)

If the signal is so low that the noise becomes disturbing it is necessary to use slower scanning speeds. The noise is then reduced by filtering. The longer the time selected to scan an image the lower the noise.

Picture # 14 displays the amount of attainable noise reduction at an exceptionally low signal for 1 s scanning speed in the lower and 360 s in the upper image half.



- The scanning speeds are adjusted with the switch **SCANNING SPEED** in positions S1 to S8. The assignment of switches and scanning speeds is as follows:

Switch position	Scanning speed	Mode
S 1	1 s	continuous
S 2	8 s	continuous
S 3	16 s	continuous
S 4	32 s	single frame
S 5	60 s	single frame
S 6	100 s	single frame
S 7	190 s	single frame
S 8	360 s	single frame

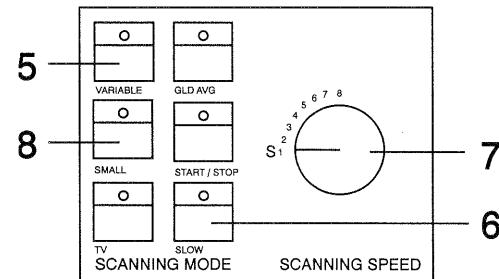
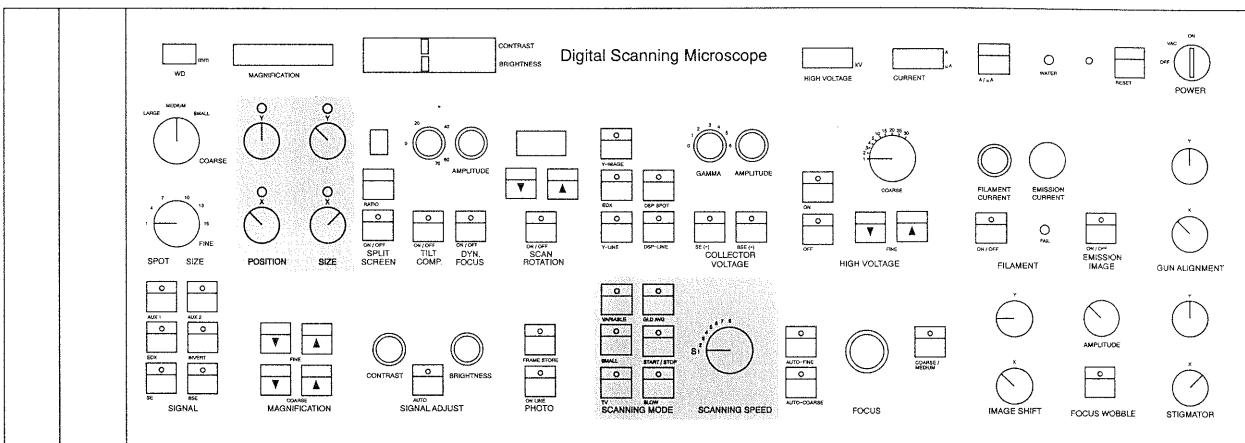
- In the positions S1 to S3 the frames follow each other immediately. Image acquisition is stopped and restarted with **START/STOP** (3).
- In the positions S4 to S8 a stop is made after each single frame. A new frame can be started with **START/STOP** (3).

In the STOP phase the beam scans the full image field on the specimen at TV frequency in order to prevent the specimen from being exposed to injurious effects of the beam at a single spot.

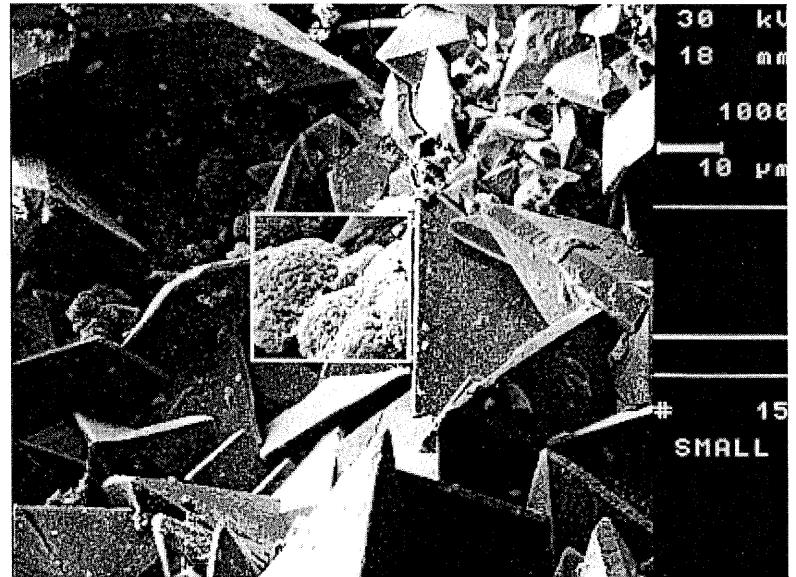
Because of the integral frame store of the DSM 960 A you will always see a full frame on the screen even in slow scan mode.

- If acquisition of the image is stopped with **START/STOP**, it is possible to switch off the beam (specimen protection), and observe and evaluate the image, which is maintained in the frame store.

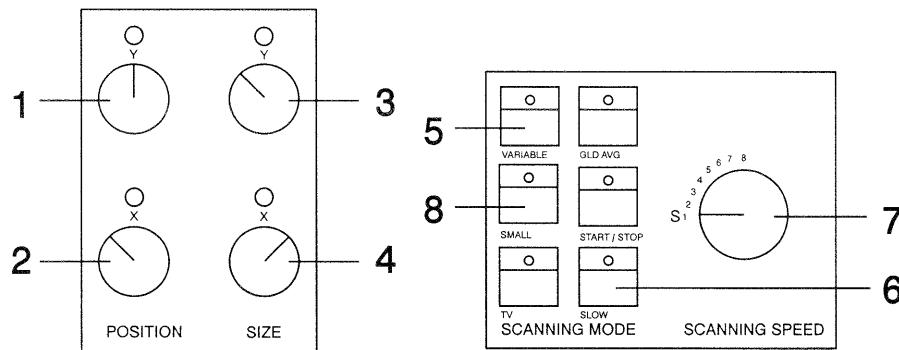
4.9.3 Reduced Raster (SMALL) (8)



In slow scan mode it is possible to switch to Reduced Raster; only a field in the center of the image is scanned, which corresponds to 1/16 of the normal image field. The smaller image field increases the scanning speed by a factor of 8; the noise is reduced as in the full field.

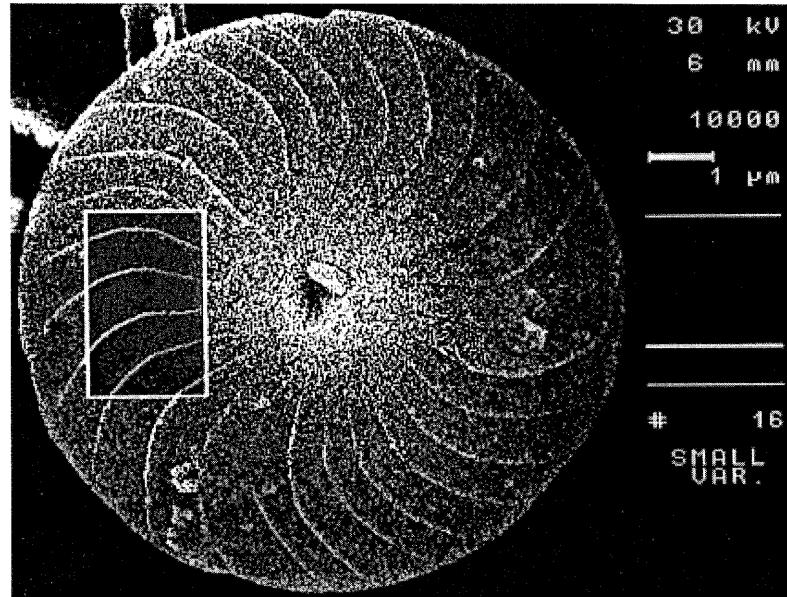


4.9.4 Variable Reduced Raster (VARIABLE) (5)



It is variable in size and position in both axes. The frame store technology allows:

- Variable window
- Stereo image pair
- Comparison of two images
- Different detectors as signal sources



Switching the variable raster on and off

- In slow scan mode the variable reduced raster is switched on with the key **VARIABLE** (5) on the front panel of the DSM 960 A. The yellow diode in the key indicates that the function is activated.

The reduced raster cannot be activated in TV scan mode.

- The variable raster is switched off (which re-activates the full frame scan) by pressing the key **SLOW** (6) or any other key in the Scanning Speed section.

Adjusting the image field

- The position of the field is adjusted horizontally with the potentiometers **POS X** (2) and vertically with **POS Y** (1).
- The field size is adjusted with the potentiometers **SIZE X** (4) (width) and **SIZE Y** (3) (height).

Applications

Increased image frequency

The time the electron beam stops at a pixel in the image corresponds to the time adjusted in slow scan mode. But as not a full frame is scanned, the time required for a frame is the shorter the smaller the image field, a fact which can be utilized for critical adjustments:

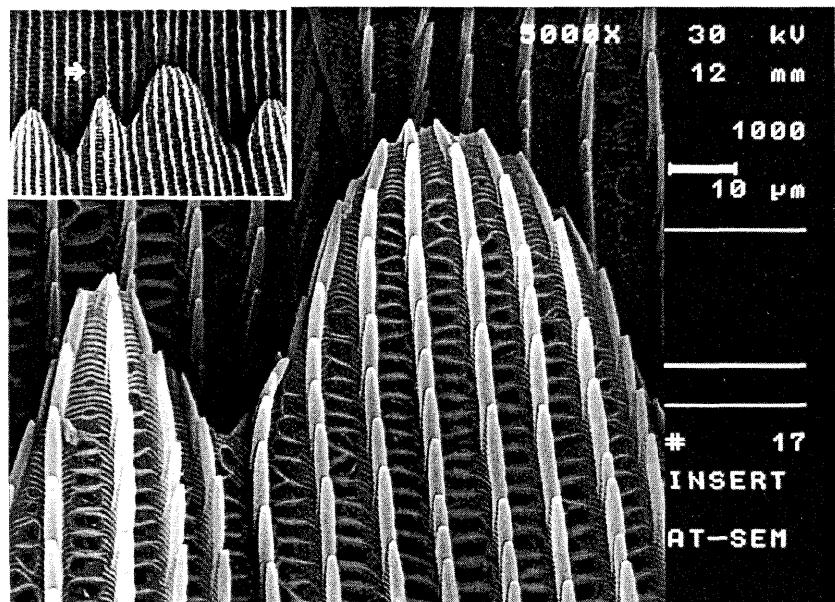
- Select slow **SCANNING SPEED** (7) and small field (high noise integration). Switch to full frame with **SLOW** (6) and acquire image.

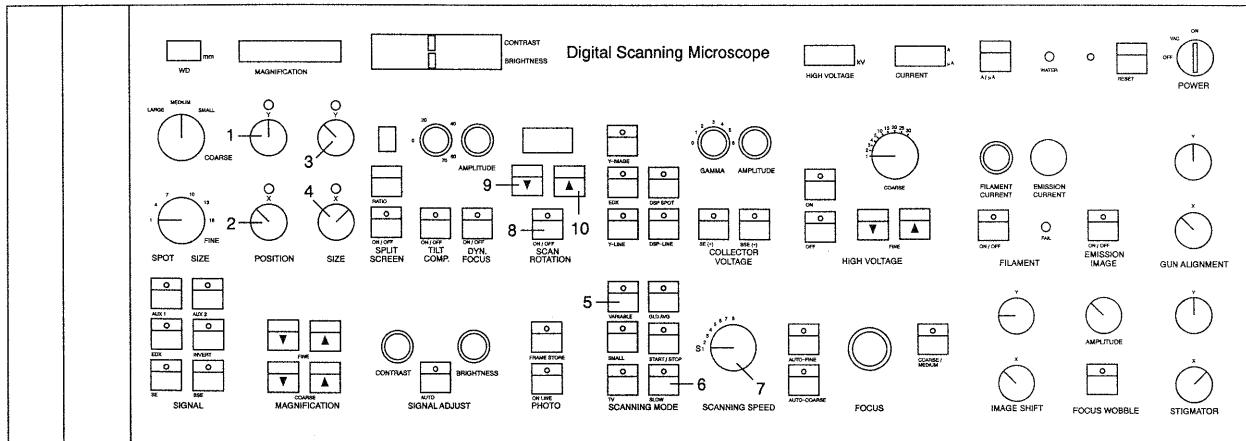
Image inserts

An inserted image can be provided in the image with the variable reduced raster.

- Define the size and position of the variable reduced raster with **VARIABLE** (5), **POS X** (2), **POS Y** (1), **SIZE X** (4) and **SIZE Y** (3), then switch off this function.
- Acquire a full frame with **SLOW** (6) and at the speed selected with **SCANNING SPEED** (7).
- Switch to **VARIABLE** (5) and acquire the image without changing position and size. All other parameters such as signal source, high voltage, magnification can be changed.
- When the inserted image is acquired, photography is possible with **FRAME STORE**.

The data in the data field refer to the last adjustment, here to the parameters of the insert. The parameters of the full frame may be entered in the data field in the user line or into the image field.





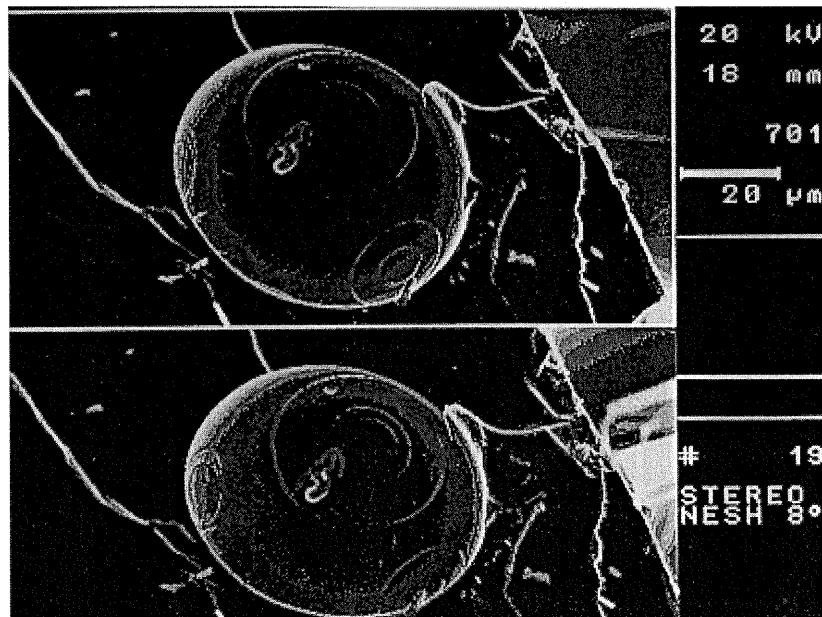
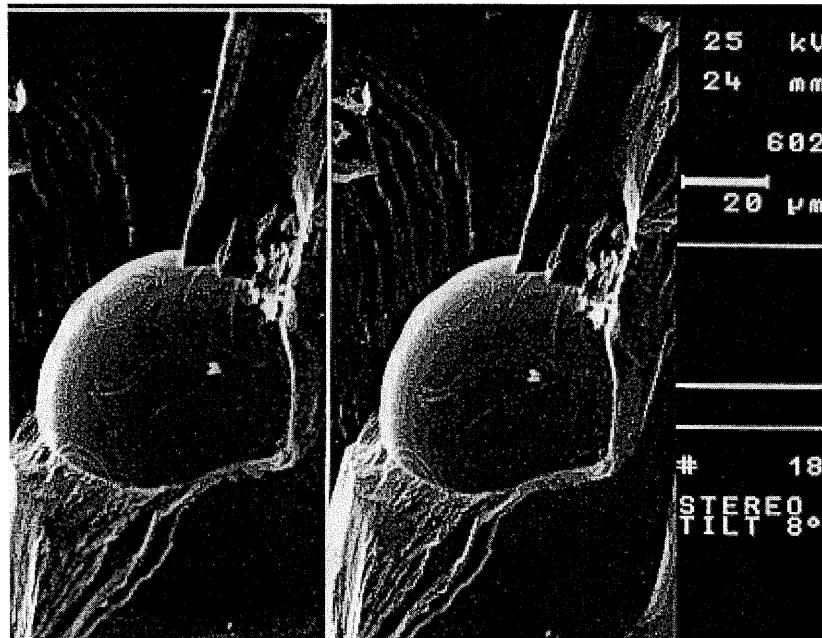
Stereo pairs

Two basically similar procedures are possible:

- a) The stereo images lie side by side for observation with the unaided eye, stereo magnifiers or mirror apparatus.
 - b) The stereo images lie on top of each other for observation with prism spectacles (Nesh system).

In both cases the specimen must be in the eucentric point of the specimen stage (for details see 3.4). The specimen feature can then be tilted without shifting off the field.

Now adjust with Scan Rotation the tilt axis which is usually horizontal to coincide with the vertical axis.

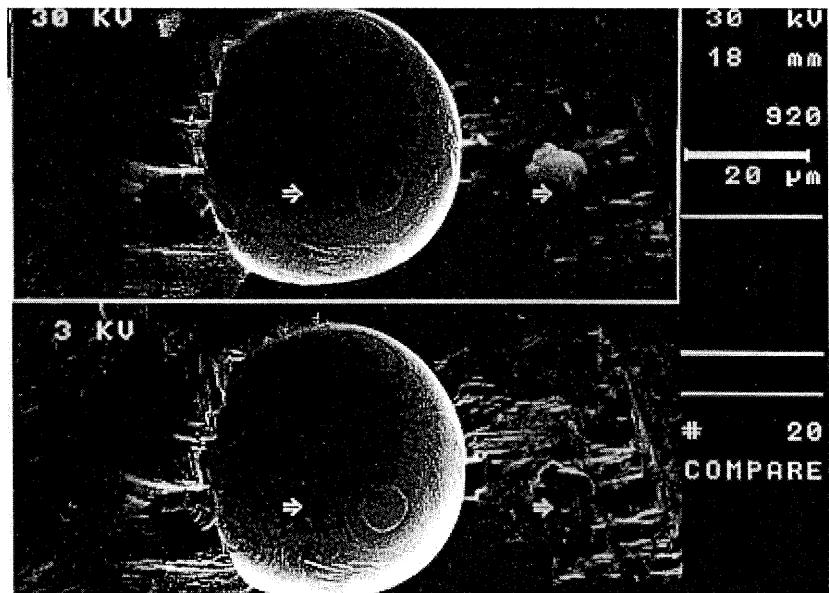


- Switch on Scan Rotation with **SCAN ROTATION ON/OFF** (8), and turn the raster with (9) or (10) so that the tilt axis is parallel to a vertical edge. Control this adjustment by a feature which moves along a vertical line when shifted with the X drive (which is now the Y drive!).
- Split the image field vertically with **VARIABLE** (5), **POS X** (2) and **POS Y** (1), **SIZE X** (4) and **SIZE Y** (3) as described under b) above, and acquire an image in the first half.
- Move the frame quickly to the left as described under a) with **POS X** (2) or down according to b) with **POS Y** (1). Now move the specimen feature with the Y drive (now the X drive) according to a) or with the X drive (now the Y drive) according to b) to the new image field and adjust until the image has the same appearance as before. Tilt the specimen (4° to 8° are typical) and acquire a new image. It is possible to observe the image stereoscopically already on the monitor.
- Photograph with **FRAME STORE**.

Comparison of two images

Other than with Split Screen, parameters can be used here, which cannot be changed quickly, e.g. high voltage, different specimens, etc.

- Adjust the image field with **POS X** (2) and **POS Y** (1), **SIZE X** (4) and **SIZE Y** (3).
- Acquire image
- Split the image field, shift frame and specimen and adjust (or exchange specimen), set new parameters and acquire reference image.
- Photograph with **FRAME STORE**.



Different detectors as signal sources

With the Split Screen function you simply switch the signal sources between the displays. Here it is also possible to combine other signal sources, but these are not simply switched over, e.g. an SE detector with normal and a BSE detector with inverted contrast. Or, an SE detector with change between SE and BSE by changing the collector potential. Splitting of the image into four fields with 4 different signals is also possible.

These are merely a few examples of many possible applications. All methods use the frame store and you must use **FRAME STORE** for photographic documentation.

4.9.5 Frame integration (GLD AVG)

If the image is acquired into the frame store in normal slow scan mode the noise is eliminated for each single pixel (pixel integration):

The video signal is measured several times (depending on the speed of acquisition), the measured values are averaged, and the mean value put into the frame store at each pixel, the next pixel measured, and so on.

For frame integration one image is loaded into the frame store and then the next one started. The mean value is calculated from each pixel of the new and the corresponding pixel of the stored image, and the value put into the corresponding storage position. Max. 256 images are successively integrated and the process is stopped.

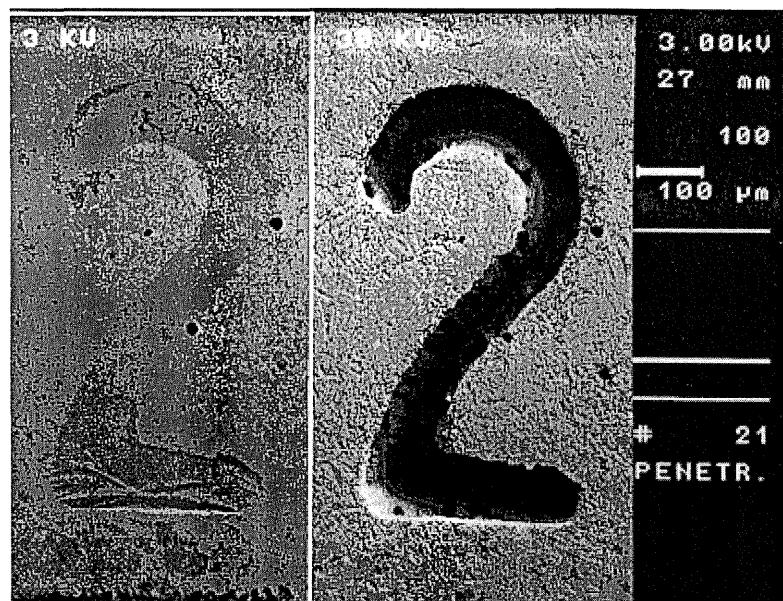
This method requires a stationary specimen which does not change otherwise. In case of changes (e.g. shift due to charges) specimen spots are averaged which do not conform, and the sharpness of the image is lost. The method is recommended for specimens which are sensitive to charging because each spot of the specimen surface is not exposed to the beam for too long.

- GLD AVG** is stopped with **START/STOP**;
- Return to normal Slow Scan mode with **SLOW**

4.10 Use of different high voltages

Which high voltage is suitable for a specific specimen is a matter of experience. Generally valid statements are not possible.

Some hints are given below, which may be helpful.



4.10.1 Depth of penetration

The depth of penetration increases with the high voltage. It also applies that the lower the atomic number of the element at the specimen the larger the depth of penetration.

Consequently:

- If the electron beam penetrates deeply into the specimen, more information in the image stems from deeper specimen layers than from the surface.
- When penetrating deeply into the specimen the beam is expanded because electrons are scattered, and the spatial resolution is impaired.

First conclusion: High accelerating voltages are useless for chemically "light" material (e.g. organic specimens), unless the specimen surface is "sealed" by a metal layer (gold) which will then supply the information.

Second conclusion: If specimens are sensitive and would be destroyed by energy absorbed from the beam, a lower potential is required to reduce the energy.

Exceptions:

thin foils and membranes where high voltage will cause transmission of the foil so that it absorbs less energy than at low voltage when it absorbs the whole beam.

Third conclusion: For the observation of coated insulators the beam should not penetrate the coating (low voltage) to prevent charging of the insulator. This charge will not be discharged again making imaging impossible.

4.10.2 Resolution

The higher the voltage the smaller the effective beam diameter on the specimen, because

- a) the electromagnetic lenses are highly energized and their aberrations are smaller,
- b) the smaller relative chromatic width of the beam reduces the chromatic aberration,
- c) the brightness of the source increases, which results in a greater number of electrons in the beam cross section,
- d) less beam deflection from nominal position by magnetic strayfields.

Smaller beam diameters generally also improve the lateral resolution, unless reasons mentioned under 4.10.1 above apply.

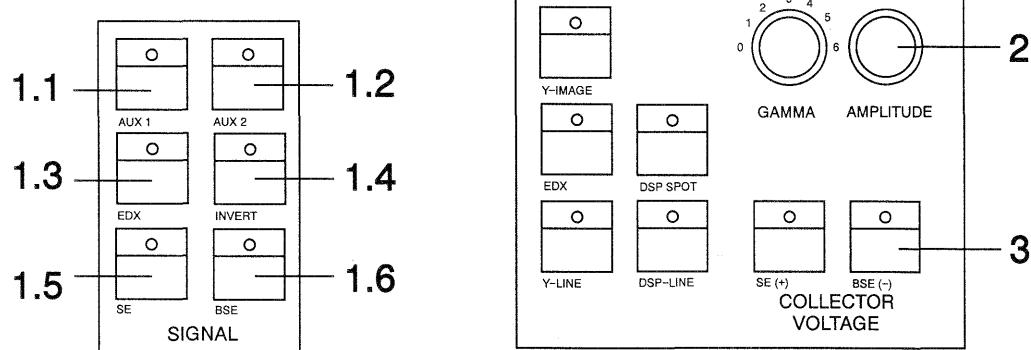
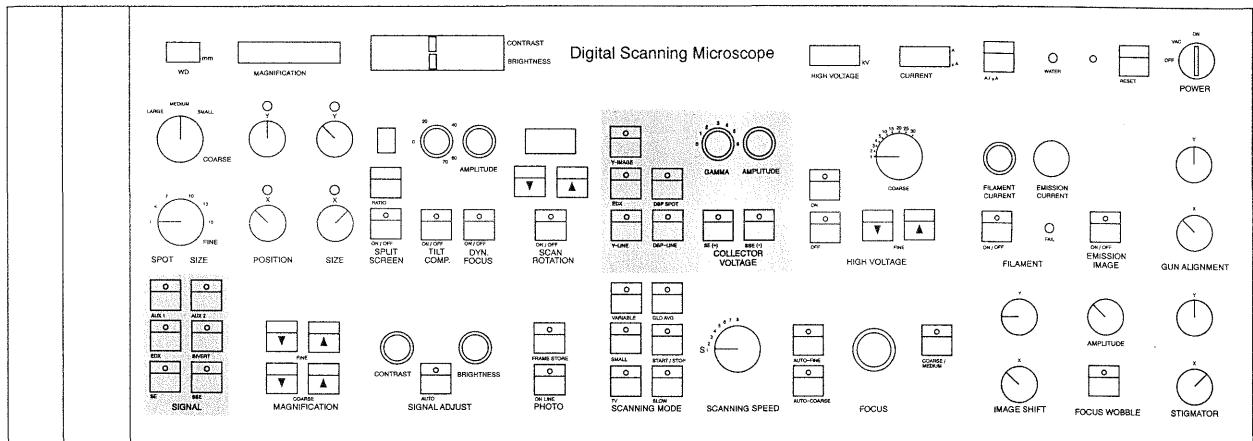
4.10.3 Charging

Charging is due to absorption of electrons in nonconducting material.

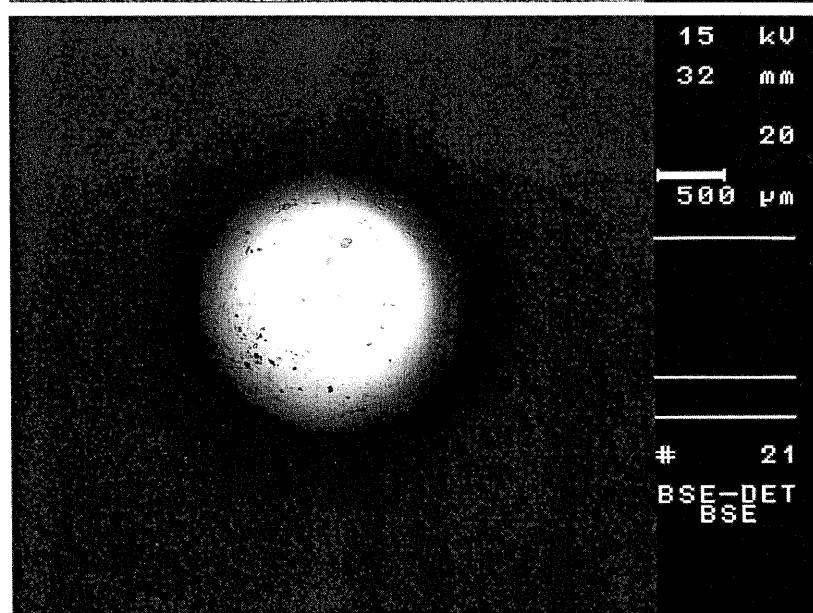
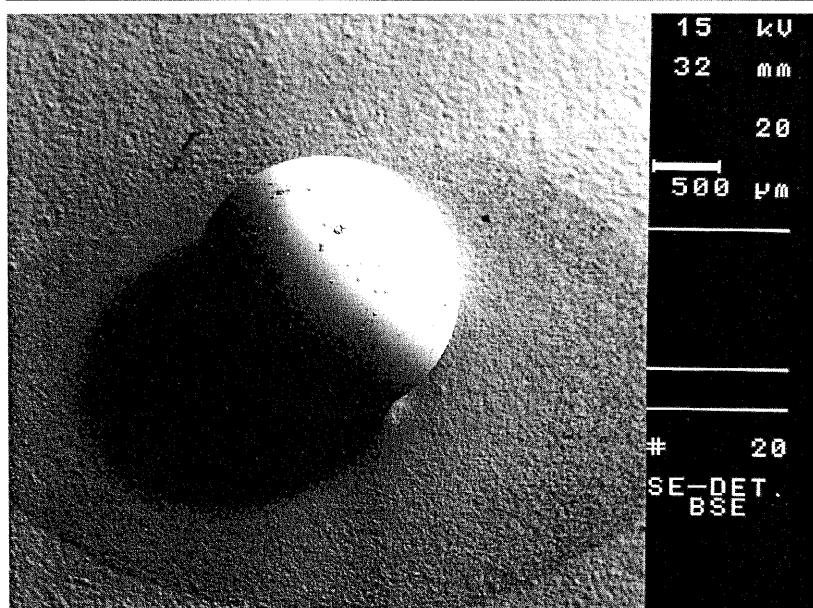
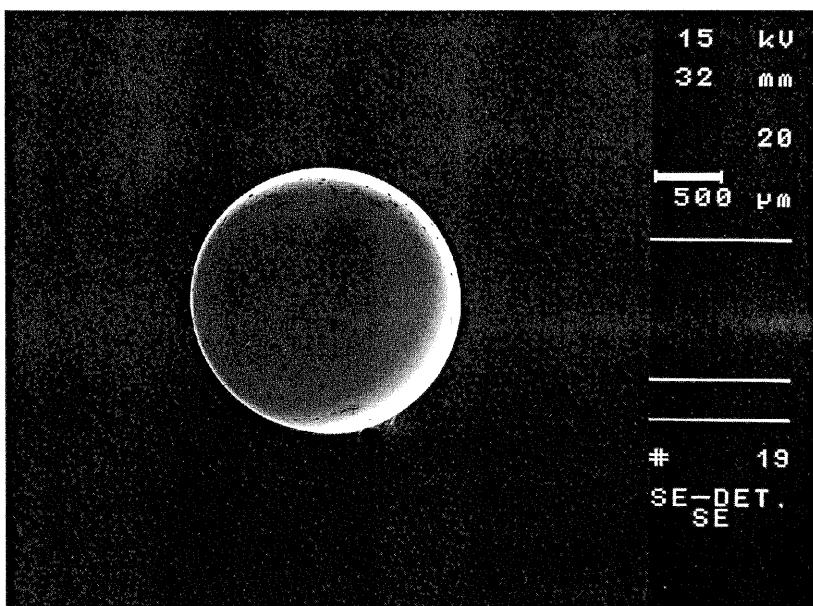
Suitable selection of the high voltage will cause more or the same number of (secondary and backscattered) electrons to leave the specimen than supplied by the primary beam.

This prevents charging. The range depends on the high voltage and the specimen material. It is generally below several thousand volts and may be exceptionally narrow, which requires precise high-voltage setting.

4.11 Use of different signals



Most applications in scanning electron microscopy use secondary electrons emitted by the specimen and picked up by a suitable detector. This signal type is automatically set with the auto-start-up parameters.



4.11.1 Secondary electrons

- Press key **SE** (1.5) in field **SIGNAL**. The lamp in the key is on.
 - Turn potentiometer **AMPLITUDE** (2) fully clockwise, which adjusts the collector potential of the **SE** detector to +400V and provides the maximum **SE** signal.
- Uniform illumination of specimen, bright fringes: edge effect (image # 19).

4.11.2 Backscattered electrons

- The percentage of **SE** electrons in the image can be constantly reduced with potentiometer **AMPLITUDE** (2).
- Pushing **BSE** (3) causes potential inversion; decrease to -250 V by turning the potentiometer fully clockwise.

Only backscattered electrons which travel linearly to the scintillator will contribute to the image. All electrons up to -250 V are kept away from the detector.

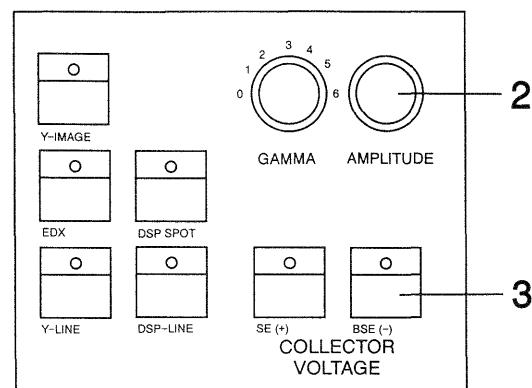
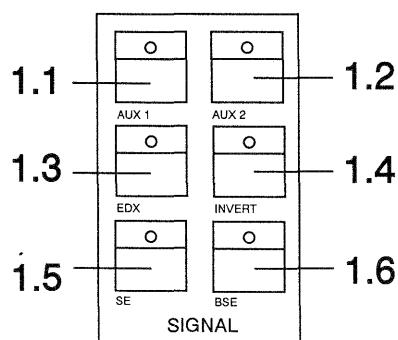
- Picture in the middle # 20: spot illumination of specimen, sharp shadows, no edge effect.

4.11.3 Backscattered electrons (BSE detector accessory)

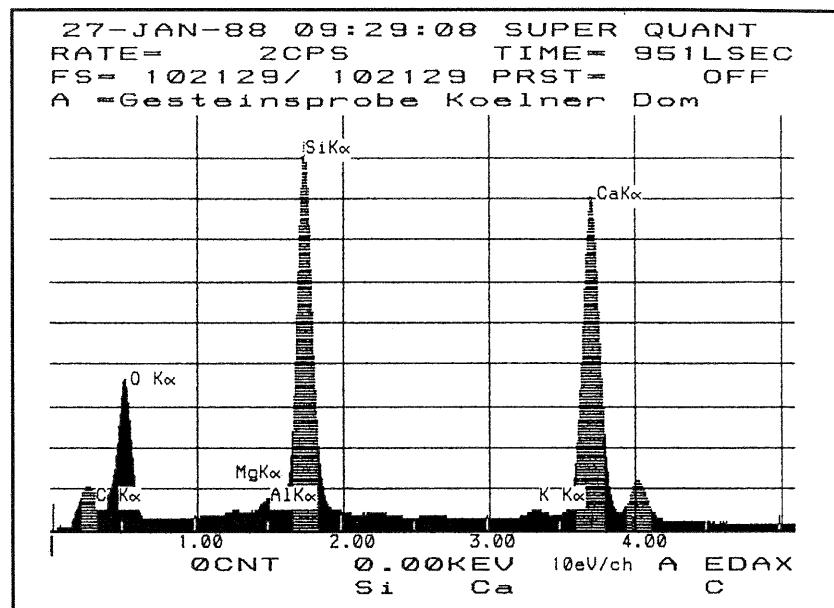
Contrary to the BSE image produced with the SE detector the BSE detector produces diffuse illumination which suppresses most of the specimen topography but reveals the Z contrast (element contrast).

- It is activated with **BSE** (1.6) in **SIGNAL**.

Picture on bottom (# 21) low surface contrast, clearly displayed material differences.



4.11.4 EDX-Mapping



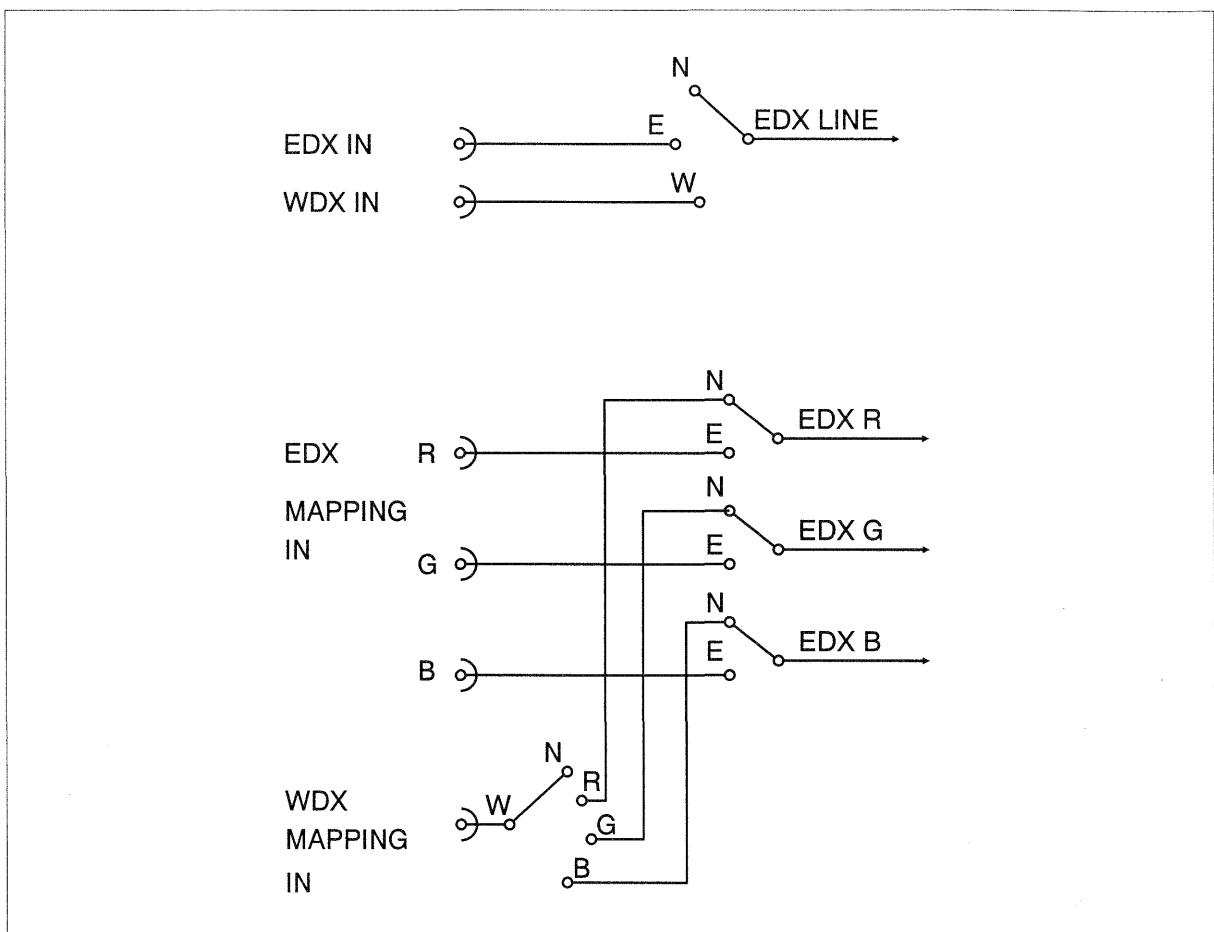
1. Field of application

The EDX mapping interface connects the DSM with an energy-dispersive or wavelength-dispersive X-ray microanalysis system.

With this interface elemental maps and concentration profiles can be displayed on the monitor of the DSM and photographed.

If the DSM is equipped with a colour monitor 3-element distributions can be displayed in pseudocolours; one primary colour (red, green, blue) is assigned to each element.

Documentation is made in colour by colour hard copy units.



2. Functional principle

a) Ratemeter inputs (EDX IN / WDX IN)

The voltage supplied by the ratemeter is proportional to the count rate at a specimen spot, and the latter proportional to the concentration of the element present at this spot.

The concentration of a specific element is displayed on the monitor by an upward deflection. By scanning the specimen along a line, the concentration profile of the element is displayed on the screen.

The two rate meter inputs of the EDX and/or WDX systems can be switched on by the software, and will be effective in the operating mode **EDX SPOT-LINE**. If the level increases from 0 to 1V, the line on the monitor rises from the basic level to maximum deflection.

b) Mapping inputs**1. Generating an elemental map**

If an electron beam hits specimen spot, it releases also X-rays. A spectrum of X-rays develops which is characteristic of the element composition of the specimen in this spot.

With an EDX system a window can be set to a specific spectral line. Counting pulses which are counted into this window will also be available at the pulse output of the EDX system.

If the scanning beam is moved over the specimen, counting pulses will occur at the pulse output of the EDX system if in this specimen spot the element is present whose spectral line lies in the window. The pulse is directed to the monitor of the DSM where it generates a bright spot. A great number of these spots mark the area where the element is present in the specimen (area mapping). The spot density is a measure of its concentration.

2. EDX mapping inputs (EDX MAPPING IN)

With a modern EDX system several windows can be set simultaneously to different spectral lines; they will also be available as pulse outputs. The DSM provides for this mode: 3 channels can be selected by the software, assigned to either of the primary colours red, green or blue, and displayed on the colour monitor.

If element images overlap because 2 or all 3 elements are present simultaneously, the images are displayed in the corresponding mixed colours.

3. WDX mapping input (WDX MAPPING IN)

If the WDX spectrometer is adjusted for a specific element, an image of the distribution of this element can be displayed with the pulse output. The colour of the display can be selected by the software.

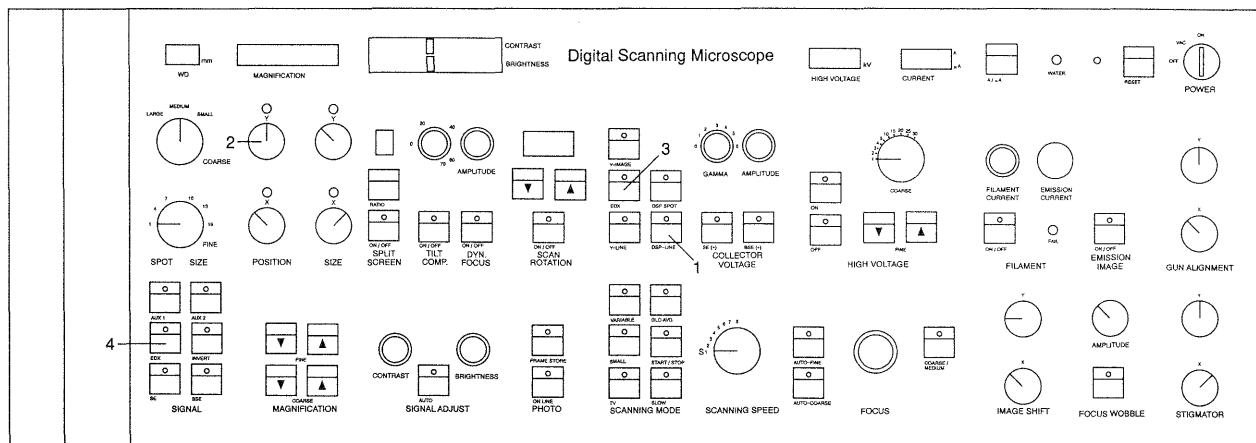
4. Count rate adjustment

Noise in the detector crystal of the X-ray microanalysis system or Bremsstrahlung from the specimen may generate counting pulses even if no characteristic X-rays were excited. These pulses form an unwanted parasitic, so-called background signal.

This background signal can be suppressed by setting count rate threshold which allows only count rates above the threshold to pass through.

A circuit integrated in the mapping interface represents such a threshold. It can be programmed with the count rate adjustment from 1 - 9. If it is, for example, set to 5, more than 5 counting pulses are required to unblank a specific pixel. The pixel will remain dark if the count rate is lower.

5. Operating instructions



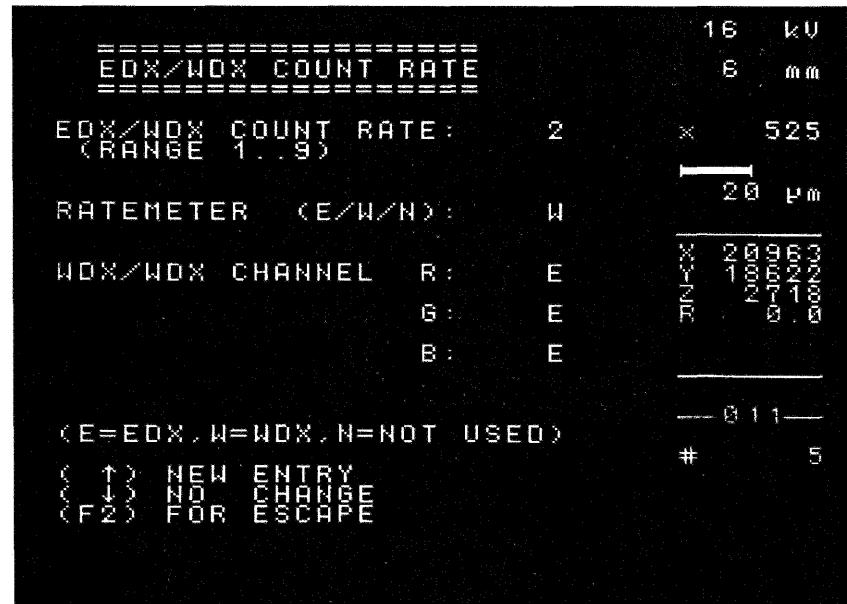
Recording of concentration profiles

Required is a rate meter on the X-ray microanalysis system (it is often retrofitted) which supplies suitable output levels (0 - 1 V DC).

Settings on the X-ray microanalysis system

Wavelength-dispersive X-ray microanalysis system (WDX)

- Set the spectrometer to the element and the rate-meter to the correct count rate range (see operating instructions of the WDX system).



Energy-dispersive X-ray microanalysis system (EDX)

- Set a window to the desired element and switch the window to the rate meter. Set the rate meter to the correct count rate range (see operating instructions of the EDX system).

Setting on the mapping interface

- Call the EDX/WDX count rate menu with the function key **F2** on the keyboard (**EDX, C.RATE ON/OFF**).
- Set rate meter input **RATEMETER** to **E** for EDX or **W** for WDX, switch off with **N**.
- Leave menu with **F2**.

Settings on the DSM

- Acquire an image of the specimen feature
- For a better display of the lines, darken the image more than usual with the manual exposure control.
- Switch on the line with the key **DISP LINE** (1); the LED will light.
- Set the line to the specimen feature to be examined with the Y potentiometer **POS Y** (2); with the Scan Rotation turn and align the raster on the specimen, if necessary.
- When **DISP-LINE** was selected the **SPEED**-switch does not affect the image any more.
- Select the scanning time

Use **SCANNING SPEED SLOW** and **S4** to **S8**; the following time constants should be set on the rate meter:

S4	100 ms
S5	250 ms
S6	500 ms
S7	1 s
S8	2 s

- Start profile imaging

The concentration profile is started with the key **EDX** (3).

The imaging mode is displayed in the data field above the photo number:

EDX LINE or **WDX LINE**

- If the rate meter input is not activated,

RATEMETER?

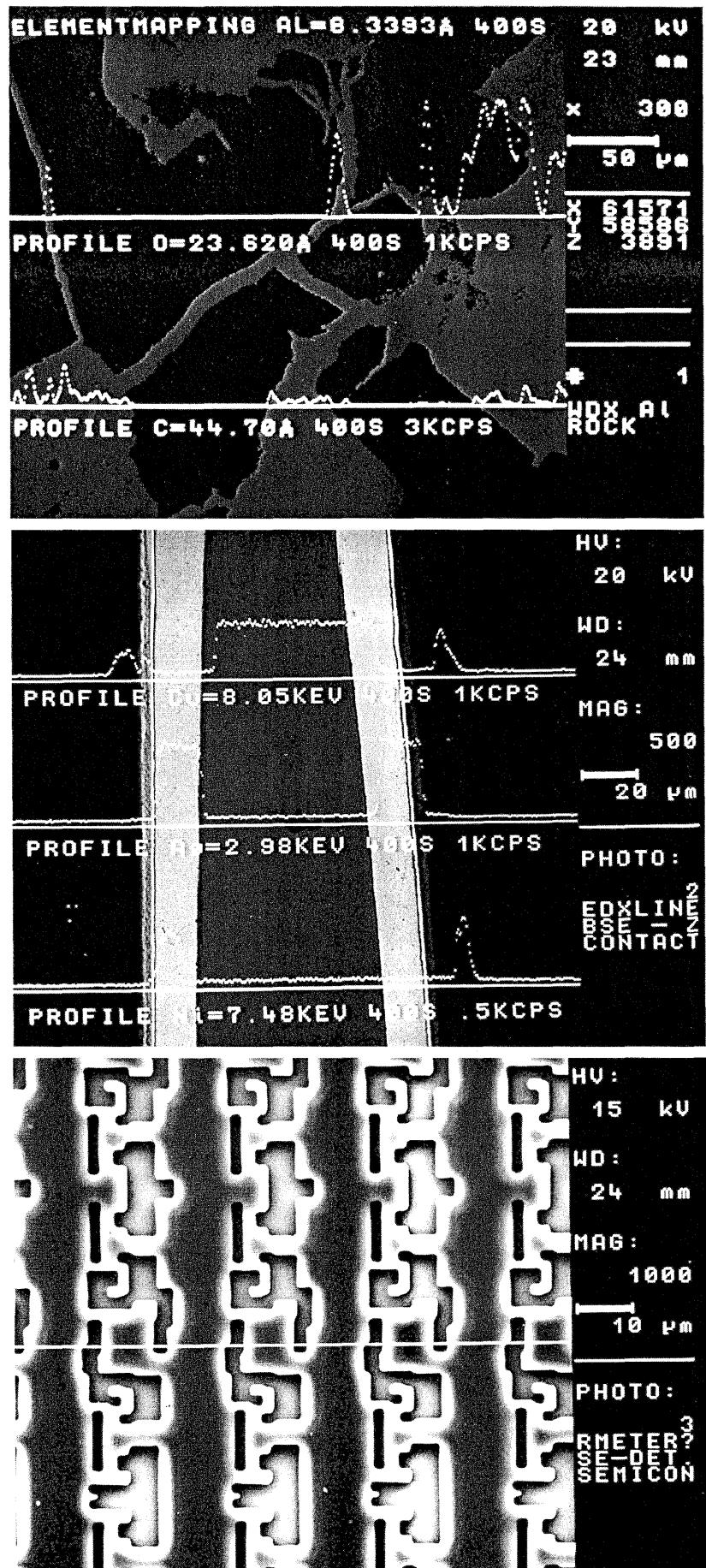
is output in line (A).

Several profiles can be written on an image by shifting the line and re-starting the profile imaging. The results are documented with Frame Store Photography.

- Terminating profile imaging

Switch off line with **DISP LINE**; LED goes out.

Start scanning with **SCAN SPEED START/STOP**; a new image is acquired which clears the lines on the monitor.



Recording of elemental maps

The X-ray microanalysis system must have outputs which supply the corresponding levels.

a) Settings on the X-ray microanalysis system

WDX system:

- Set spectrometer to element, activate mapping output.

EDX system:

- Set the windows to the desired elements and switch to the outputs.

b) Settings on the mapping interface

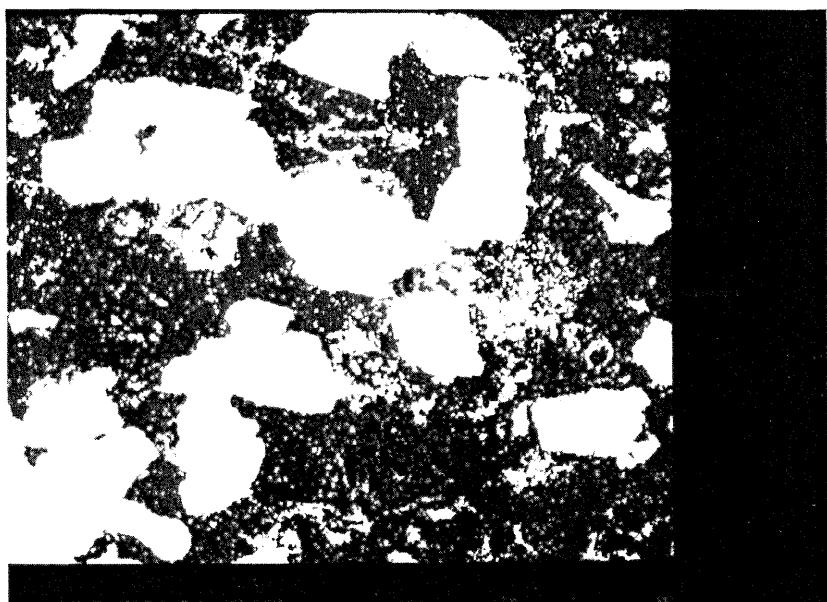
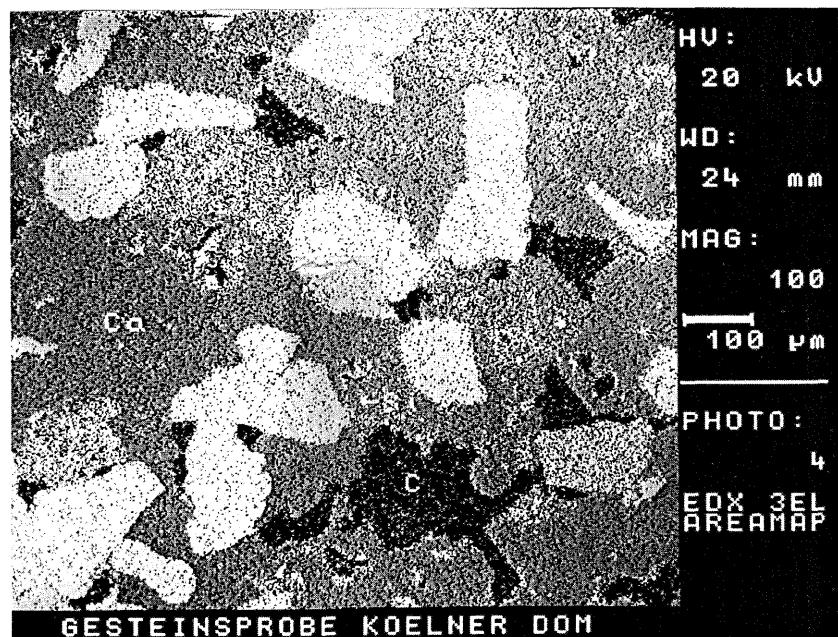
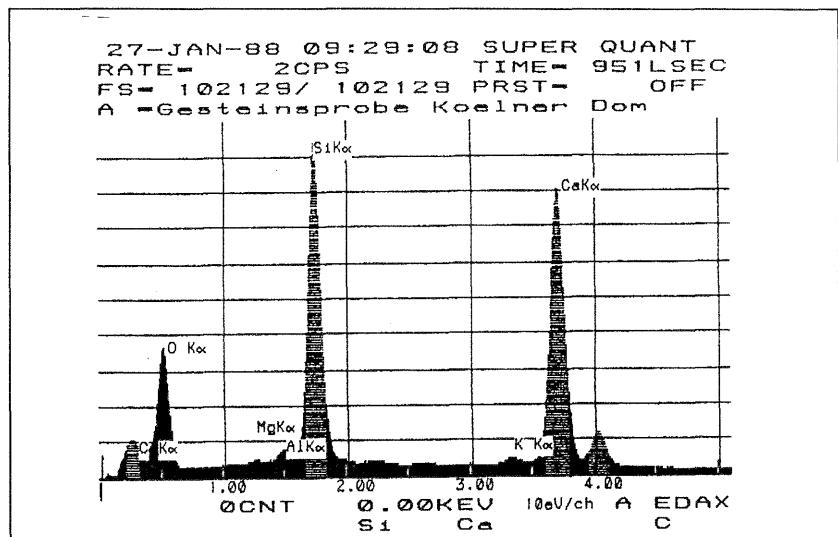
- Call **EDX/WDX count rate menu** with the function key **F2** on the keyboard (**EDX C.RATE ON/OFF**).
- Set **EDX/WDX COUNTRATE** to the range 1 to 9. A high count rate setting can be selected for better background subtraction if the count rate is high and the scanning times are long.
- Select channels on **EDX/WDX CHANNEL** for EDX (**E**) or WDX (**W**), or switch off with (**N**). A new input can be activated with **cursor up** (**▲**). To skip a value unchanged, the cursor can be moved down with **cursor down** (**▼**).
- Leave the menu with **F2**.

c) Starting elemental mapping

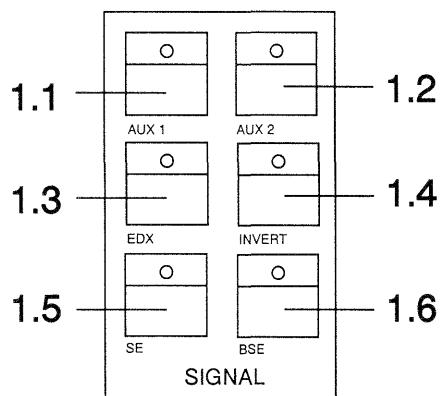
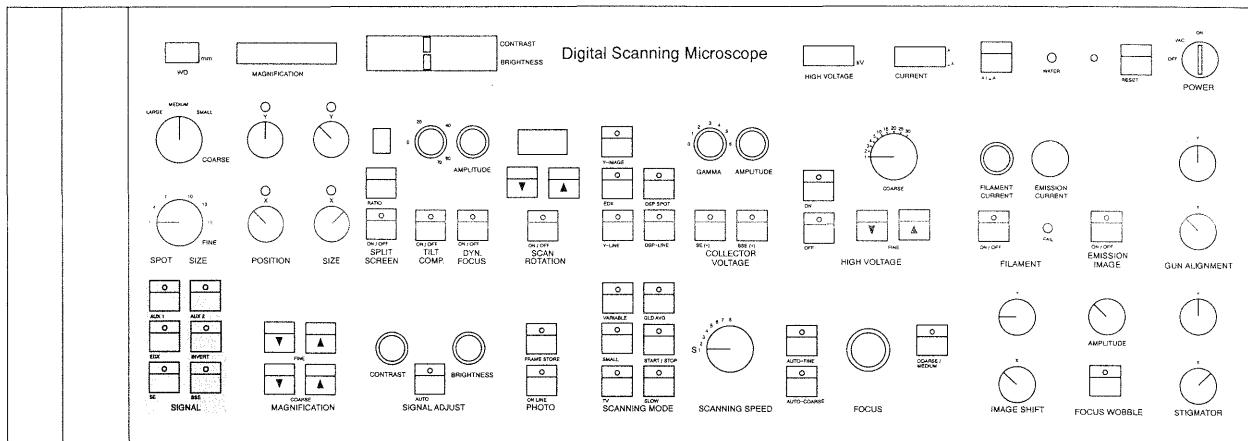
- Adjust recording time with **SPEED**, preferably with **S6** to **S8**. The longer the scanning times the better the pixel density.
- Switch to mapping inputs with **SIGNAL EDX(4)**.
- Recording starts.
- Multi-colour maps can be documented with a colour hard copy unit (accessory).
- If the pixel density is high enough, a black-and-white image scan can be recorded.
- The different elements are then displayed as different gray levels.

The gray-level display can be improved by "folding" the gray levels:

- Start the folding with **CONTROL V** of the keyboard.
- Let the image pass through completely.
- Operate **CONTROL V** again until the display is optimised (the operation must generally be repeated 3 to 4 times).
- Return to original image after 8x repetition.



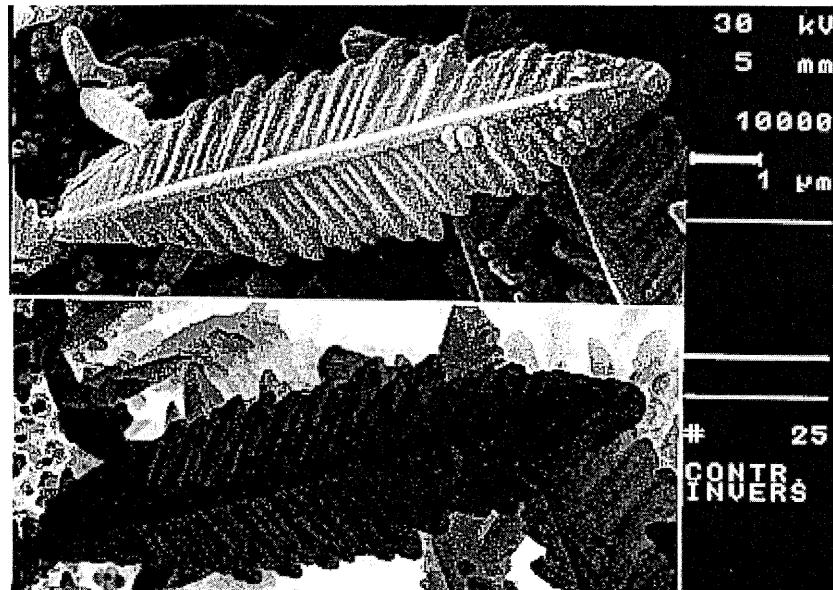
4.11.5 Contrast inversion



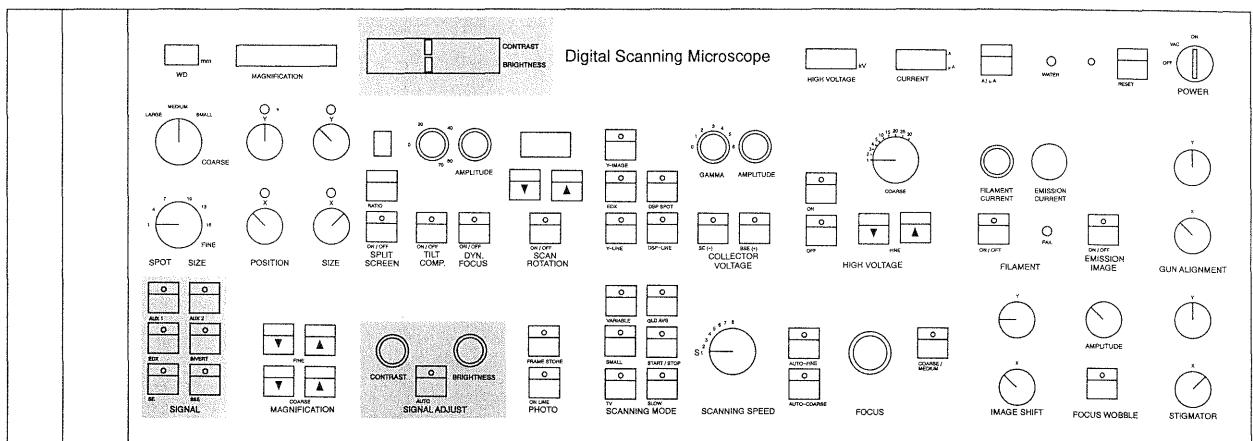
The selected signal can be inverted with **INVERT** (1.4) in the field **SIGNAL**.

Black becomes white and
white black: a negative (picture # 25).

AUX 1 (1.1) and **AUX 2** (1.2) are auxiliary inputs for attachments; they are not used in the base instrument.



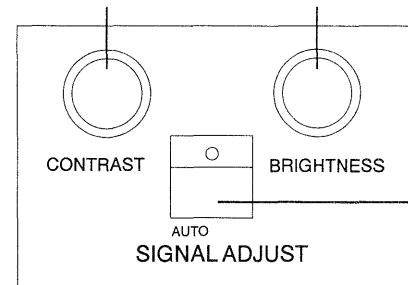
4.12 Adjustment of signal levels



20

3.1

3.2



4.12.1 Automatic brightness and contrast control

In base state the DSM 960 A is adjusted for automatic brightness and contrast control.

The lamp in the key **AUTO** (3.3) is on and the brightness and contrast displays (20) are in the green fields. Brightness and contrast are set to preselected values independent of the signal level of the specimen, which guarantees a good image on the monitor at all events.

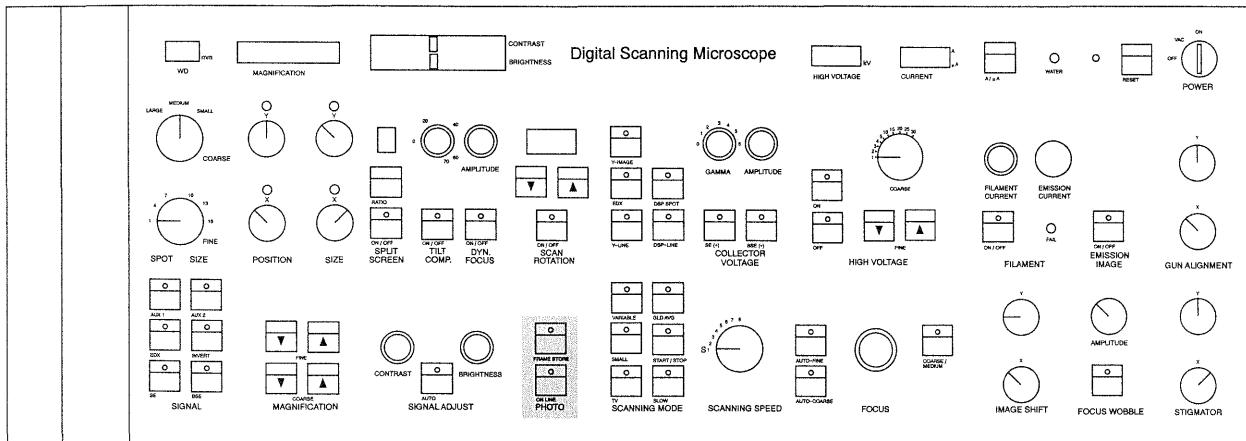
4.12.2 Manual brightness and contrast control

If signals are noisy it may be desirable to use brightness and contrast values other than given by the automatic control.

- Pushing the key **AUTO** (3.3) overrides the automatic control, the lamp in the key is out.
- The potentiometers **BRIGHTNESS** (3.2) and **CONTRAST** (3.1) and the corresponding displays (20) are activated.
- If the displays are in the red fields to the right or left, turn down the contrast and adjust the brightness so that the display is in the green region.
- Then turn up the contrast and reduce the brightness.

Both displays (20) should be in the green fields for photography.

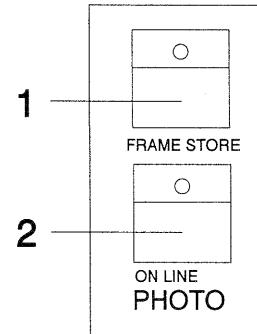
4.13 Photography



There are two photographic documentation options:

- **Frame Store:**
photography from the frame store
- **On Line:**
photography directly from the specimen

The photo number is automatically increased by 1 after each exposure.



4.13.1 Frame Store

- Exposure start with the blue key **FRA-ME STORE** (1); the lamp in the key is on during exposure.

After exposure the data field disappears shortly from the screen. If it is visible again, the lamp in the key goes out, the exposure is terminated (recording speed approx. 15 s).

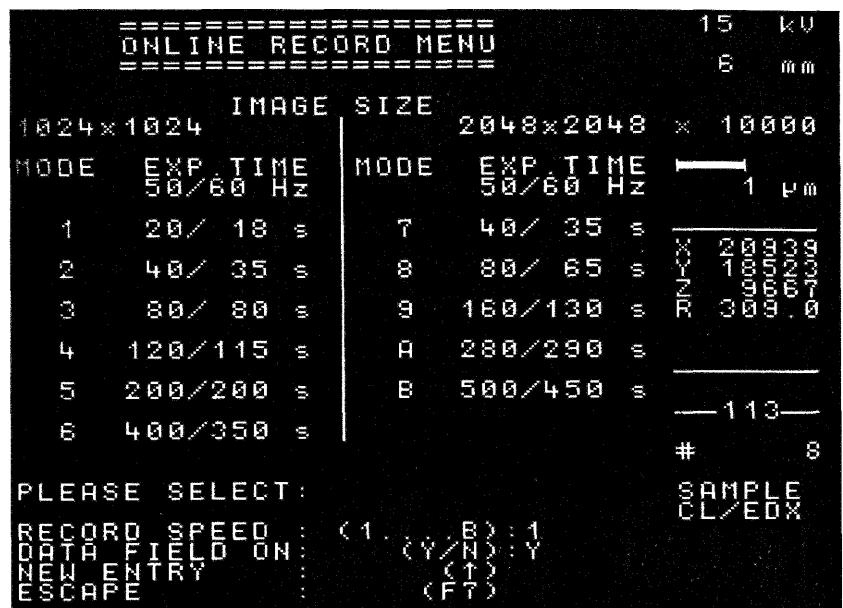
The resolution of the image of 512 x 512 pixels corresponds to the size of the frame store.

On-line photography is recommended for re-enlargements or printing rasters. Documentation which requires the frame store (e.g. inserted image) is possible only in Frame Store mode.

4.13.2 On Line Exposure

- Start with the yellow key **ON-LINE** (2).

The lamp in the key is on during exposure. In on-line photography the video information is recorded directly on film and not displayed on the screen. A continuing line is projected at the right edge of the screen to monitor the scanning beam. When this line arrives at the bottom of the image the data field disappears. If it is visible again the lamp in the key goes out, the exposure is finished. The image resolution of 1024 x 1024 pixels or 2048 x 2048 pixels allows full utilization of the lateral resolution of the fluorescent screen in the photographic unit.



Adjusting the recording speed

The speed for on-line photography is adjustable in steps from 20 s to 500 s. High speeds are possible if the signal permits; noisy signals require lower speeds.

- The on-line photography menu is activated with the **function key F7** (top row on keyboard).

The above menu is displayed on the monitor.

The displayed speeds are called up by entering a number between **1** and **9** or letters **A** to **B**. This speed remains active until another one is entered, even if the instrument is switched off intermittently.

If you want to change the entered speed, press the **cursor up key (▲)**, which resets the cursor to the input line for selection of another speed.

For multiple exposures the data field can be switched off. Return to normal scanning mode by pressing **F7** again.



Special note:

for escape from a menu press the same key used for activation.

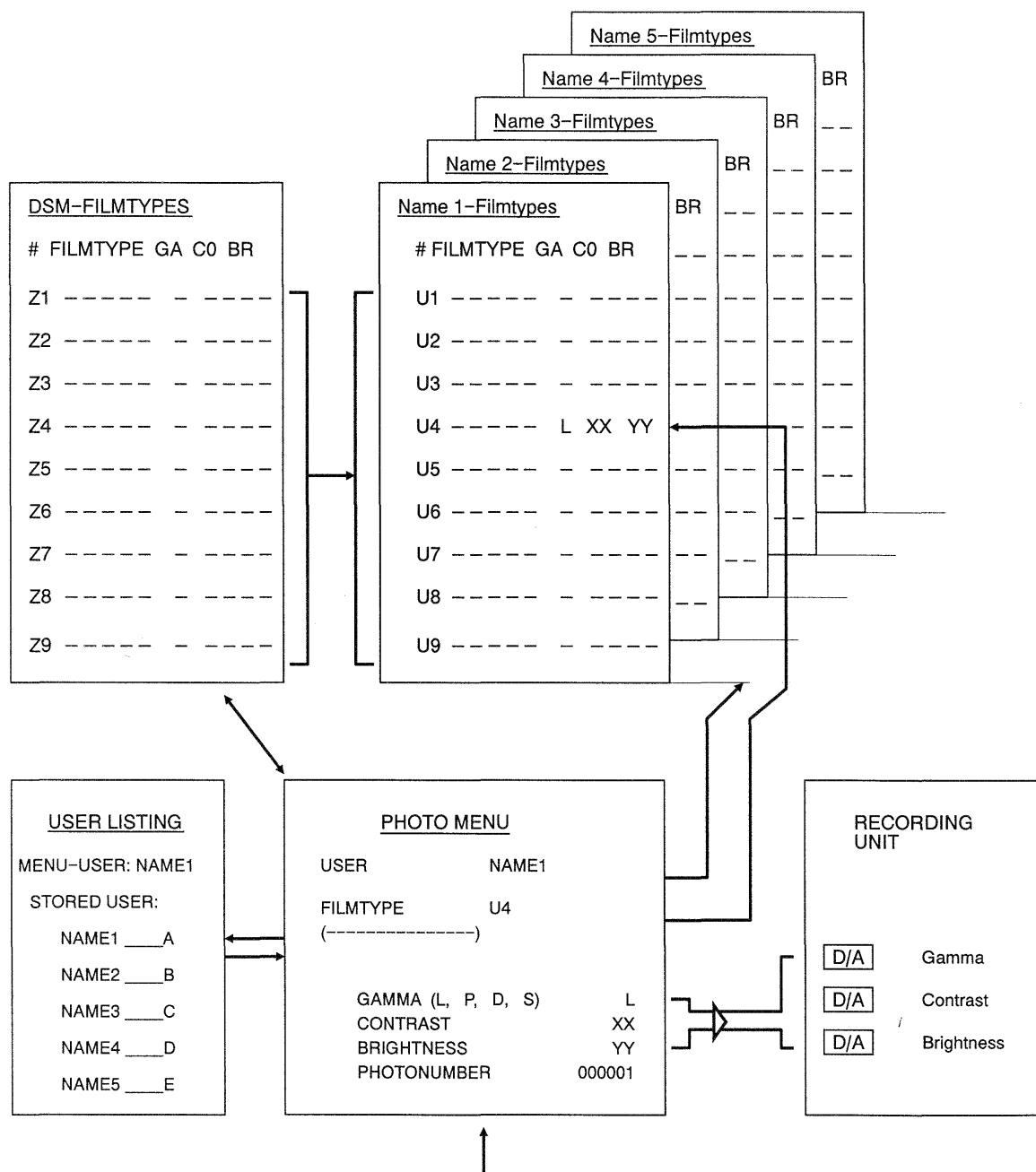
Break-off on-line photography

On-line photography may be terminated in advance from the keyboard, if necessary, especially with high recording speeds. Pressing the keys **CTRL** and simultaneously **O** terminates exposure and activates return to normal scanning mode.

4.13.3 Calibration of photographic unit

The photographic unit may be calibrated for different film speeds. After calibration the values are called up by means of a special Menu, which assures the reproducibility of the adjustment.

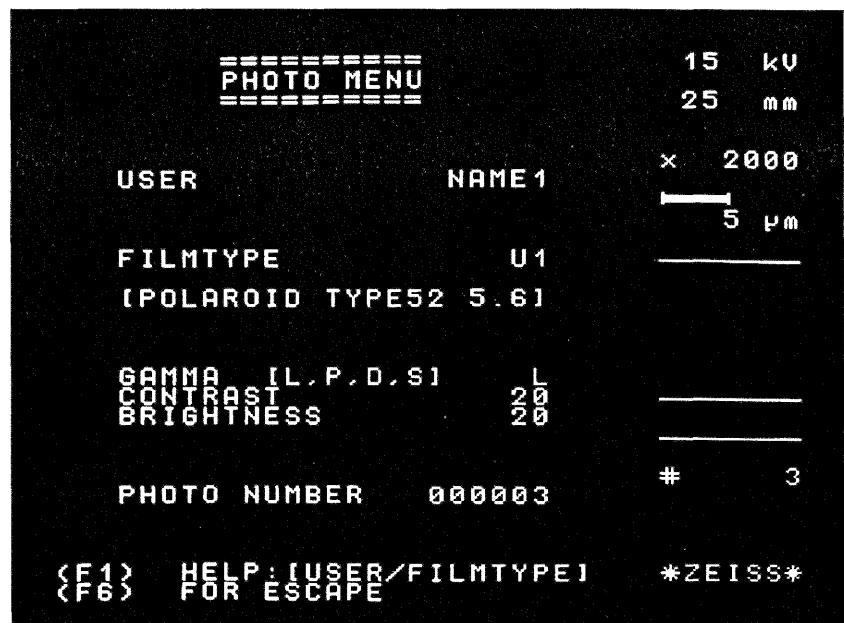
Calibration structure



It is assumed that the instrument is used by different users who have different opinions about exposure. One parameter list each is available for 5 users; each list has a capacity of 9 entries (lists 1 to 5 are shown in the above picture).

In a further list Zeiss suggests settings for 9 film types. The parameters are handled, set and called up from the photo menu.

Photo menu



- It is called up with the **function key F6**, displayed as in the above picture (# 3), and identified by the top line

PHOTO MENU

The menu accesses the parameter list of a user whose name is displayed in the next line:

e.g. **NAME 1**

The parameters used to program the photographic unit are given in line 3 (e.g. FILM TYPE U1).

The parameters are explicitly stated in the following lines:

GAMMA (L, D, P, S)
 L = linear
 D = degressive
 P = progressive
 S = S correction

Gamma is used for adjustment to the gamma value of the film.

CONTRAST

settings from 1 to 99; the number 99 corresponds to maximum contrast with setting 55 for 400 ASA film (18 DIN).

BRIGHTNESS

settings from 0 to 99; the number 99 corresponds to maximum brightness.

PHOTO NUMBER

displays the number under which the next frame will be recorded.

- Return to normal scanning mode with **function key F6**.

Adjusting the frame number

- Call up the photo menu with the **function key F6**.
- Set cursor to the frame number either with **RETURN** or with the **cursor down key (▼)**.



Special note:

with **RETURN** the photographic unit is adjusted to the values given in the menu, but the cursor key leaves the adjustment of the photographic unit unchanged!

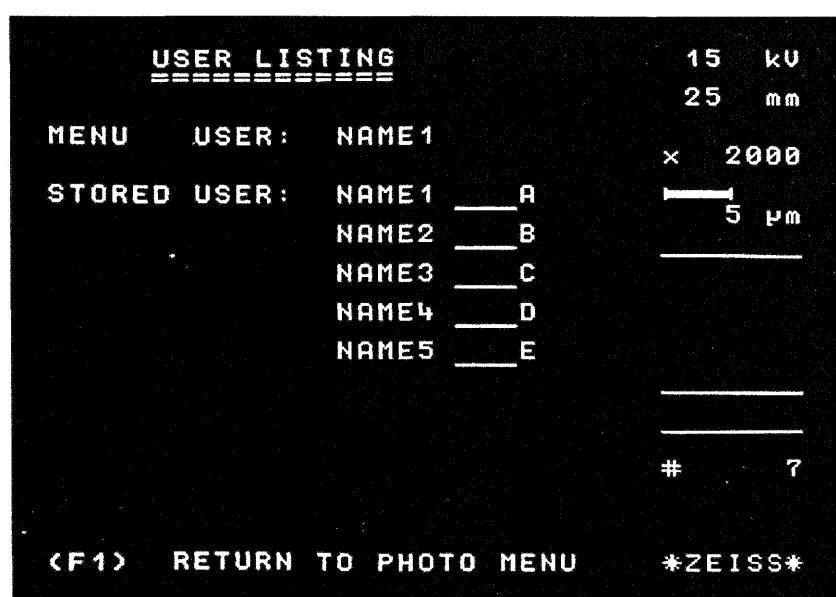
If the cursor is at the photo number a new number may be entered from the keyboard; leading zeroes of a photo number with less digits must also be entered.

Example: photo number 125 correct entry: 000125
 wrong entry: 125

Return to scanning mode with **function key F6**; the new photo number is entered in the data field. Incrementing after each photo as from this photo number.

Calling up the user list (USER LISTING), picture # 7

The list contains the names of all users and may be called up to check the entries.



- Call up the photo menu with the **function key F6**.
- If the cursor is in the **USER** line, the user list can be called up with the **function key F1**. The names of the users are entered under **A** through **E**, with the name of the present user in the headline.
- Return to photo menu with **function key F1**.

Adjusting the parameter list (NAME X - FILMTYPES)

NAME 1 FILMTYPES							15	kV
							25	mm
#	FILMTYPES	AP	GA	CO	BR			
U1	POLAROID TYPE54	5.6	L	35	27	x	2000	
U2	POLAROID TYPE55	5.6	L	30	35			5 μm
U3	ILFORD FP4	120	5.6	L	22	22		
U4	ILFORD PANF	120	5.6	L	25	25		
U5	EKTACHROME	64		8	L	22	22	
U6	EKTACHROME	200		8	L	20	20	
U7	ILFORD FP4	135		8	L	21	21	
U8	AGFA PAN	200	5.6	L	33	33		
U9	POLAROID TYPE52	5.6	L	20	20	#		11

{F1} RETURN TO PHOTO MENU *ZEISS*

{F2} CALL DSM FILMTYPES

A new user may call up his personal parameter list.

- Call the photo menu with the **function key F6**.

The cursor is in the line with the user's name.

- The name of the new user is entered in this line, acknowledged with **RETURN**.

The new parameter list is activated, and the last photographic setting used in this list programmed and displayed by the menu.

Calling up the parameter list (NAME 1-FILMTYPES)

- Call up the photo menu with **function key F6**.
- Adjust the parameter list to be displayed as described above.

The cursor will be in the film type line.

- Call up the parameter list with the **function key F1**.
- Return to photo menu by pressing **function key F1** again.

Calling up the DSM parameter list (DSM - FILMTYPES)

DSM FILMTYPES							15 kV
#	FILMTYPES	AP	GA	CO	BR		25 mm
U1	POLAROID TYPE52	5.6	L	20	20	x	2000
U2	POLAROID TYPE54	5.6	L	35	27	—	5 µm
U3	POLAROID TYPE55	5.6	L	30	35	—	
U4	ILFORD FP4	120	5.6	L	22	22	
U5	ILFORD PANF	120	5.6	L	25	25	
U6	EKTACHROME	64	8	L	22	22	
U7	EKTACHROME	200	8	L	20	20	
U8	ILFORD FP4	135	8	L	21	21	
U9	ILFORD HP5	135	11	L	20	20	# 10
{F1} RETURN TO PHOTO MENU							*ZEISS*
{F2} CALL USER FILMTYPES							

- This list is called up with the **function key F2** either from the normal parameter list or from the user list. The DSM list contains films for instant photography (Polaroid P52 and PN55), sheet films and roll films for the 35mm camera, which may be transferred to the individual parameter lists. Return to base menu by pressing **function key F2** again.
- Direct return to photo menu with **function key F1**.

Entry of a new user

- Call up the photo menu with **function key F6**.
- Enter the name of the new user in the user name line and press **RETURN**. Five alphanumeric characters are allowed for the entry.
- If the name is not included in the list, the menu jumps automatically to the user list and the corresponding parameter list can be selected with any letter between **A** and **E**.

The parameter list (from **A** to **E**) is now assigned to the name of the new user. The values of the adjusted film are also loaded in the corresponding line of the parameter list (U1 - U9).

Transfer of DSM parameters to personal parameter list

- Call up the photo menu with **function key F6** and press **RETURN**.

The cursor will be in the film type line.

- Jump to personal parameter list with **F1**. Adjust the corresponding line from U1 to U9 with cursor up (\uparrow) or cursor down (\downarrow).
- Now copy the line of the DSM list (e.g. Z4) by entering it (e.g. **Z4 RETURN**). If the DSM line is not known select DSM parameter list with **F2** and return with **F2**.

The copied line can be edited. The name of the film or the parameters can be changed within the given limits.

- Terminate with **RETURN** and return to the photo menu with **F1**. The photographic unit is adjusted to the new values.

Adjusting the photographic unit to values from the parameter list

- Call up the photo menu with **function key F6**
- Call up the parameter list with **USER** name.
- Enter the line with the desired film type (e.g. **U3**) in the corresponding line of the parameter list.
- If you do not want to call from your personal but from the DSM list, use the letter **Z** (e.g. **Z5** for the parameters from the 5th line of the DSM parameter list).
- Terminate with **RETURN** to activate the parameters and calibrate the photographic unit accordingly.
- If you try to set a non-existing parameter line, < **UNIDENTIFIED FILM** > is displayed instead of the film name.

Make sure that the photographic unit is always adjusted to valid parameters.

Adjusting the photographic unit to changed values

- Call up the photo menu with **F6**.

Only the last values are displayed and may be changed:

- Select values with **cursor down** (↓) (not with **RETURN!**), change them and terminate with **RETURN**.

The values are maintained until the instrument is switched off or other parameters are called up.

Transfer of changed parameters to the parameter list

- Adjust values.
 - Key in user name, do not terminate with RETURN (which will call up the last setting), but move **cursor down** (↓) to film type line.
 - Call parameter list with **F1** and move the corresponding film type line with **cursor down** (↓) or **cursor up** (↑).
 - Enter **M** instead of **U** (from menu) and terminate with **RETURN**.
- The values from the menu are displayed in the parameter columns.
- Edit, if necessary and return to photo menu with **F1**.

Deleting films from the parameter list

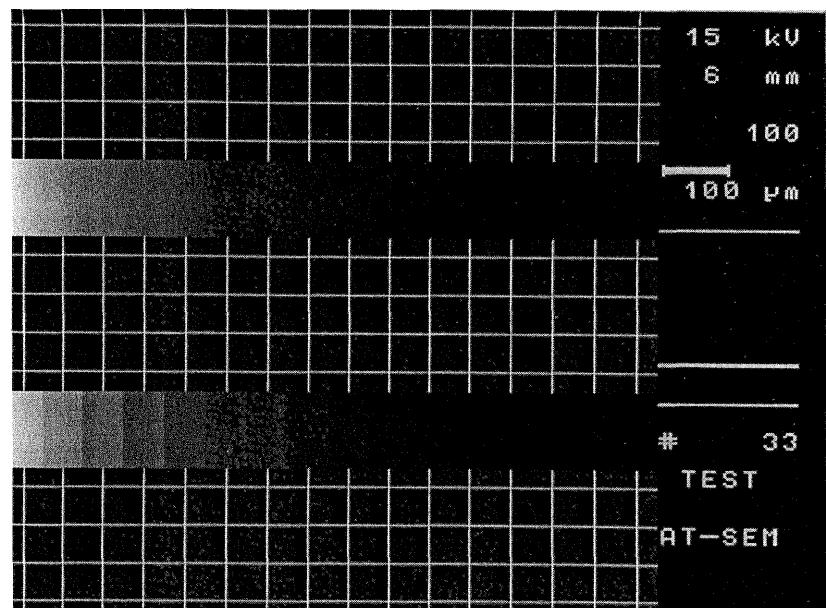
- Call parameter list.
- Move **cursor down** (↓) or **cursor up** (↑) to the line you want to clear.
- Enter **C** and **RETURN**.
- The entry is cleared and replaced by lines. Set new film parameters (different line of list), escape from the menu with **F1** and return to the photo menu.

Transfer of parameters from other parameter lists

- For a transfer adjust the parameters of the photographic unit with the other parameter list.
- Take over the values from the photo menu to your personal parameter list.

Calibrating the camera for a new film type

The DSM 960 A may be tested and calibrated by means of an electronically generated test image (see picture below # 33) which is called from the keyboard with **CTRL P**.



The grid is overlayed in the upper part by a gray wedge and in the lower part by a 16-step gray level scale. The data field is in the right margin. The values are irrelevant; they originate from the preceding scanning adjustment.

The test image can be photographed with **Frame Store**.

To calibrate a new film:

- Adjust the photographic unit to a film from the parameter lists (DSM or USER) close to the new one.
- Record image on film and evaluate according to gray level scale.
- Change photo parameters (gamma, brightness, contrast).
- If the setting is satisfactory, transfer the parameters to the parameter list.

4.13.4 Focusing the photographic unit

The photographic unit must be focused after exchange of the camera back.

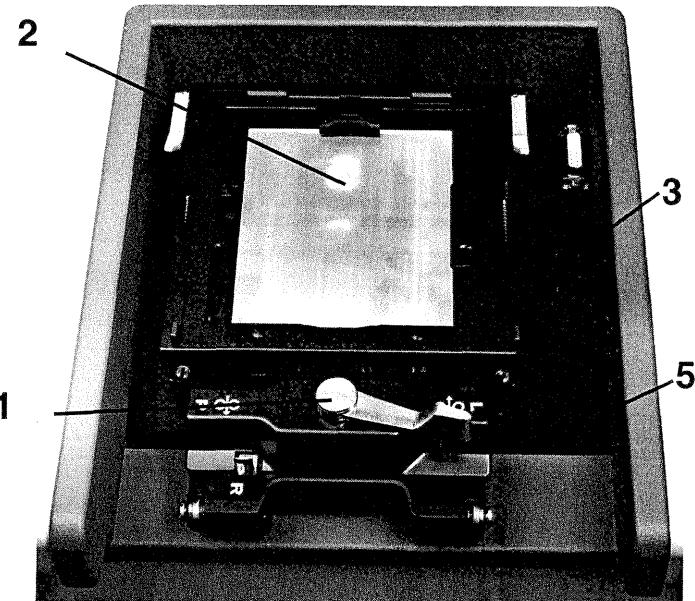
Preparation

- Remove Polaroid holder (1) and plug Allen key (SW 6) in screw (3).

Call the focusing pattern on the photo screen.

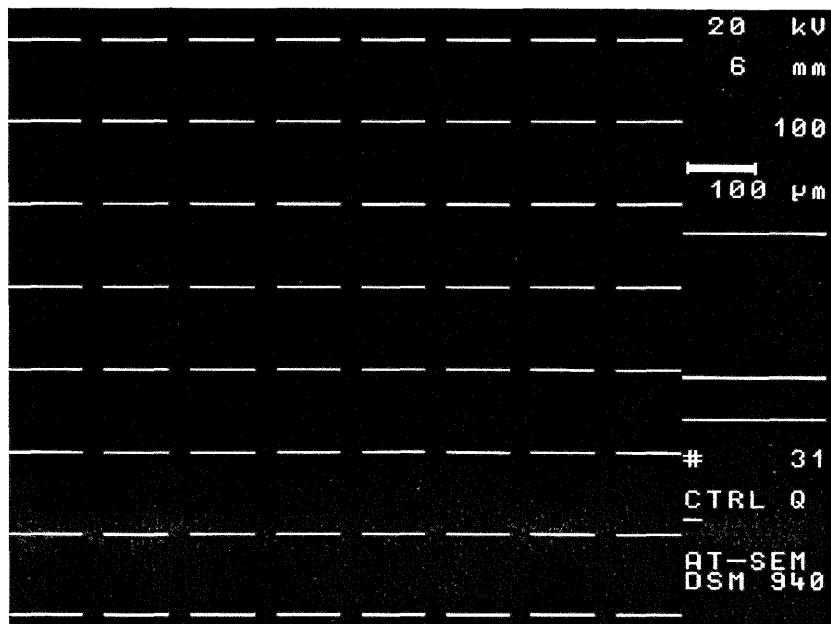
- SCAN SPEED** to TV.
- Call the test pattern by simultaneously pressing **CTRL Q** and then "1".

The test pattern will be visible for approx. 2 minutes and is then switched off automatically.

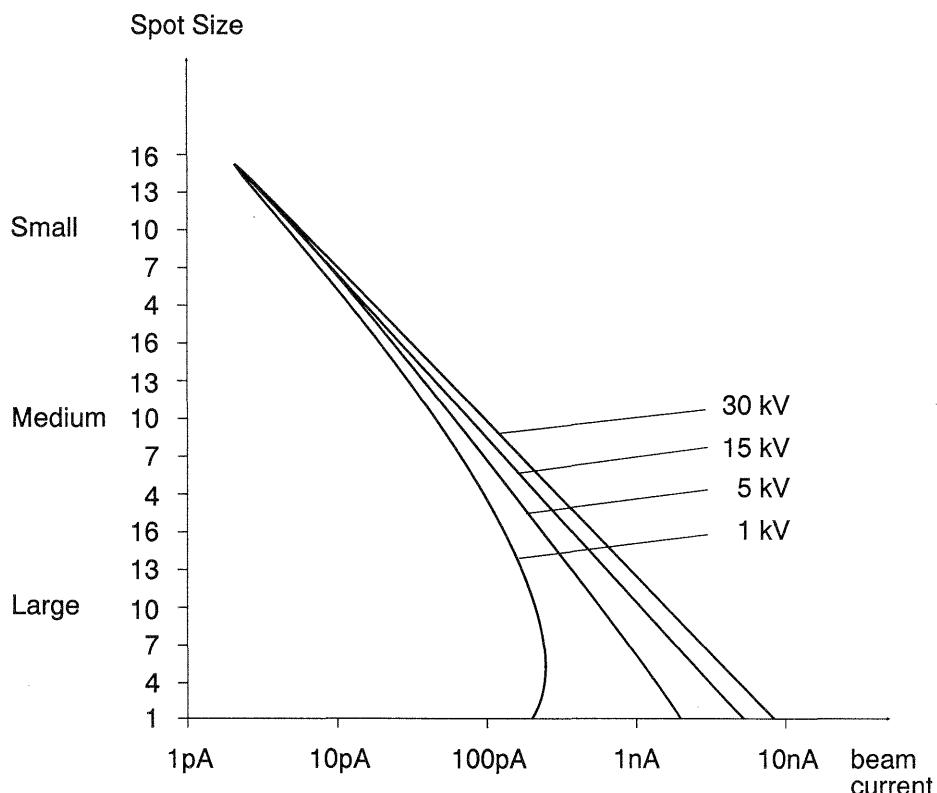


Focusing

- With the Allen key move plate (5) so that the test pattern is in focus on ground glass (2).
- Use a magnifier, if necessary.
- The visible lines are broken lines.



4.14 Adjustment of different beam currents



The beam current (current of the primary beam on the specimen) must be adapted to the specimen and/or the examination method. The beam current should be low for sensitive specimens to prevent damage of the specimen by irradiation.

High currents are allowed for massive specimens with good thermal conduction. High beam currents are required e.g. for wavelength-dispersive X-ray microanalysis. For energy-dispersive X-ray microanalysis adjust a medium beam current so that the maximum counting rate permitted by the EDX system is not exceeded.

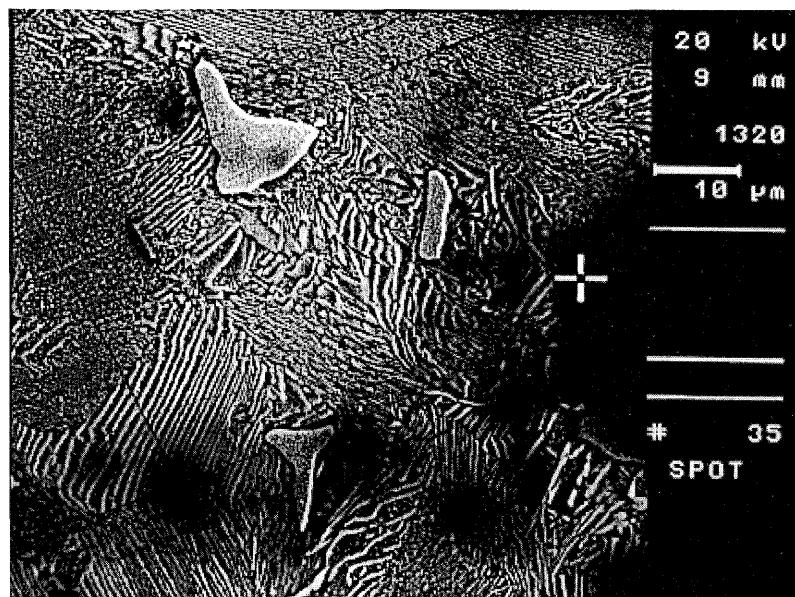
- The beam current is adjusted with **SPOT SIZE COARSE/FINE**.
- SPOT SIZE LARGE** refers to high, **SPOT SIZE SMALL** to low beam current.
- FINE**, as of 1 for the high, up to 16 for the low beam current range, further divides the coarse values.

The beam current varies with the aperture size. The smaller the aperture the less current passes through. The beam currents for the different magnification ranges are given in chapter 4.8. The beam current settings for a 70 µm aperture are displayed in the diagram above. For other apertures the following factors apply approximately:

$$\begin{aligned}
 40 \text{ } \mu\text{m} &= 33 \% \\
 100 \text{ } \mu\text{m} &= 2 \text{times} \\
 120 \text{ } \mu\text{m} &= 3 \text{times} \\
 160 \text{ } \mu\text{m} &= 5.2 \text{times} \\
 200 \text{ } \mu\text{m} &= 8.2 \text{times} \\
 400 \text{ } \mu\text{m} &= 32 \text{times}
 \end{aligned}$$

4.15 Special scanning modes

4.15.1 Spot mode



In spot mode the scanning process can be stopped and the beam set to a spot on the specimen, which is important for analytical examinations (EDX or WDX).

- Press **SPOT**.

The lamp in the key is on.

A cross becomes visible in the image. The center of the cross defines the position of the beam on the specimen.

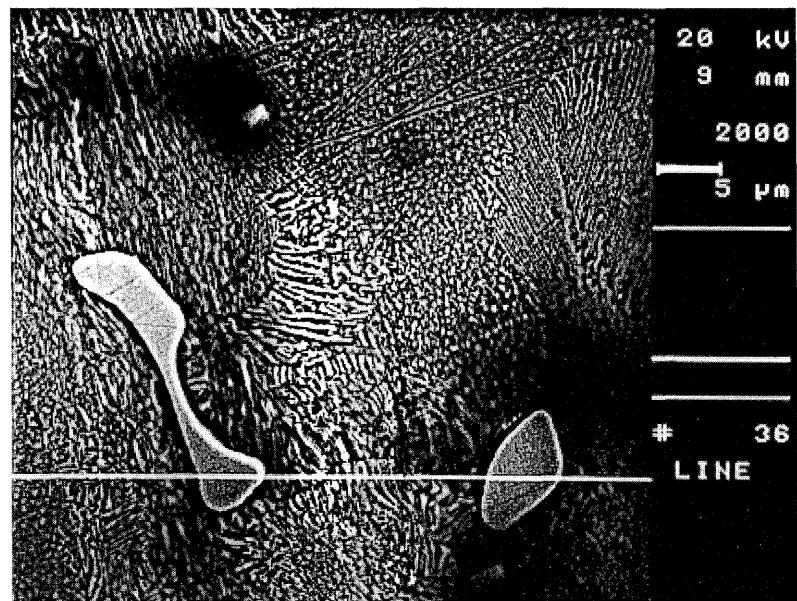
- With potentiometers **POS X** and **POS Y** adjust the cross to the specimen area selected for examination.
- Change to spot mode by pushing the key **EDX** next to the key **DISP SPOT**.

The beam is now set to the adjusted spot and measurement can be made.

- Return to normal scanning mode by pressing key **DISP SPOT** again.
Restart of scanning with **START** or selection of another scanning time.

The lowest magnification is limited when calling spot mode to avoid thermal overload of the scanning coils.
(at working distance of 25 mm it is 32 times).

4.15.2 Line scanning

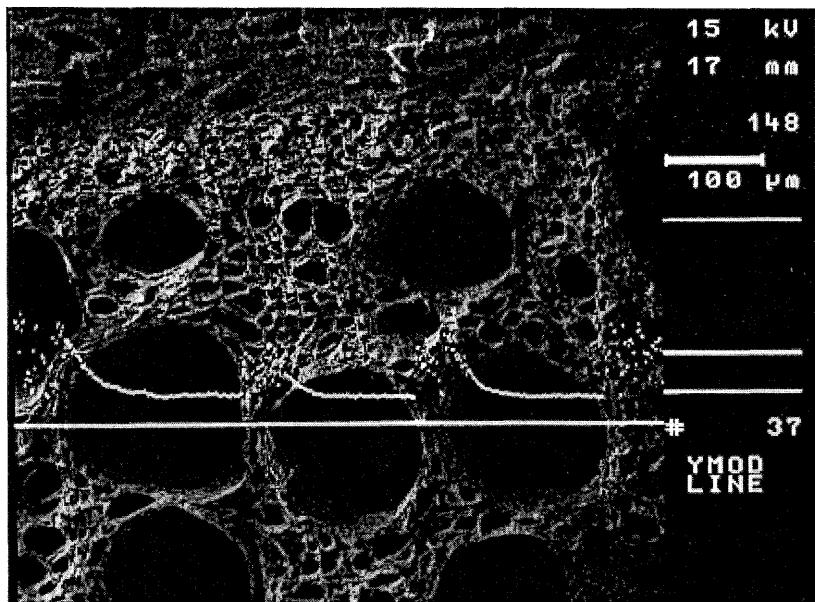


Instead of measuring at a spot of the specimen you can also measure along a horizontal line.

- Pushing **LINE** overlays a reference line on the image.
- With the potentiometer **POS Y** adjust this line to the specimen area selected for examination.
- With the scan rotation the specimen can be aligned with reference to the line.
- Line scan is started by pushing the key **EDX** next to key **DISP SPOT**.
- The selected scanning time for the image also determines the scanning time for the line.
- Return to normal scanning mode by pressing key **DISP SPOT** again.
- Restart of scanning with **START** or selection of another scanning time.

The lowest magnification is limited when calling line mode to avoid thermal overload of the scanning coils.

4.15.3 Y-modulation along a line



The imaging of a signal amplitude in the Y direction is referred to as Y-modulation. The beam intensity is of constant brightness as known, for example, from an oscilloscope.

The brightness signal along the line is used here as measure of the deflection in the Y direction.

- Adjust the position of the line according to 4.15.2.
- Press **Y-Mod Line**
- The signal along the line is acquired and overlaid on the image.

It is possible to overlay several lines, to better visualize the Y modulation curve.

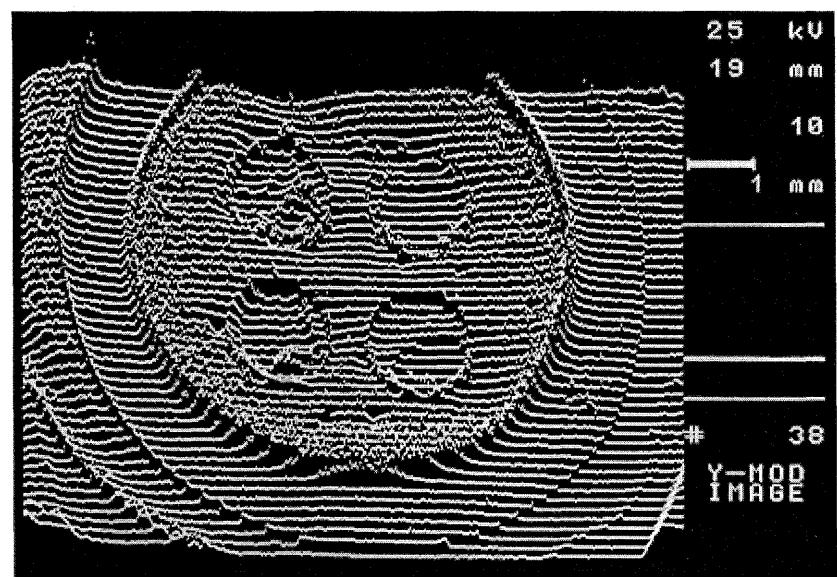
Several lines may be displayed at different locations on the screen and photographed by means of **Frame Store**.

- If video information is not wanted, the screen may be cleared with **CTRL C** (see 4.17.3).
- Y-modulation may be acquired with scanning speeds as selected with the switch **SCANNING SPEED**.

The frame times as from S2 to S8 apply now for the line times. **S1** generates a repetitive scan and the background information is cleared. It thereby acts as a wave form monitor.

- Return to normal scanning mode by restart of scanning with **START**.

4.15.4 Y-modulation of full frame



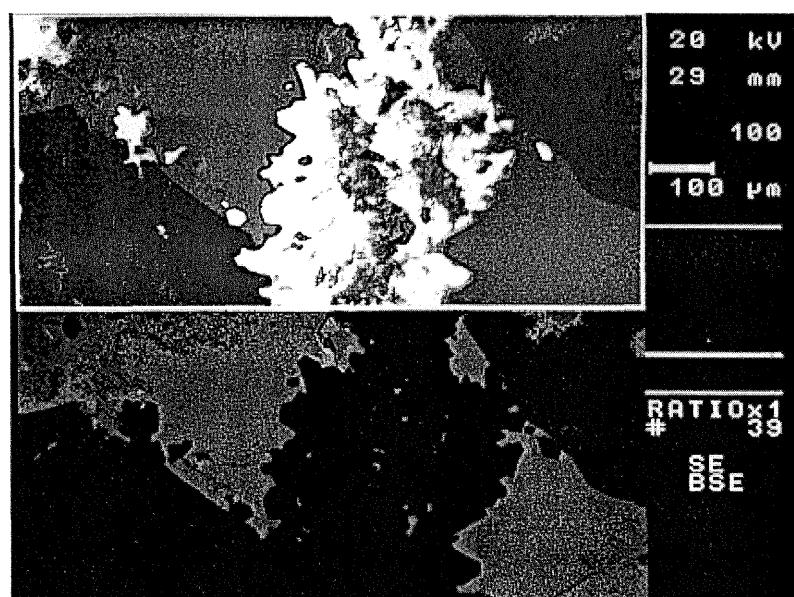
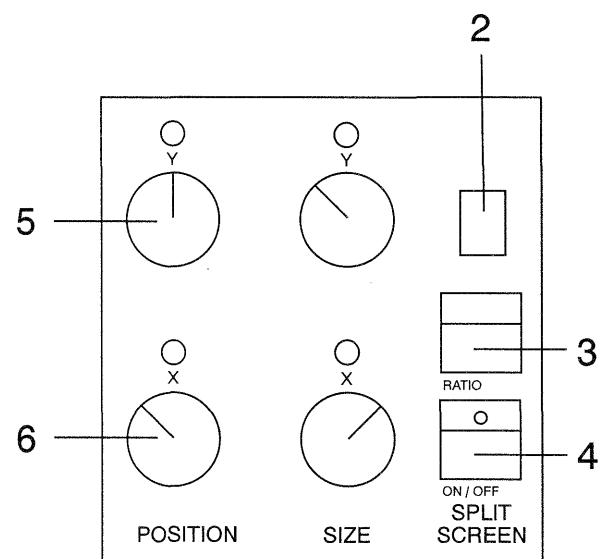
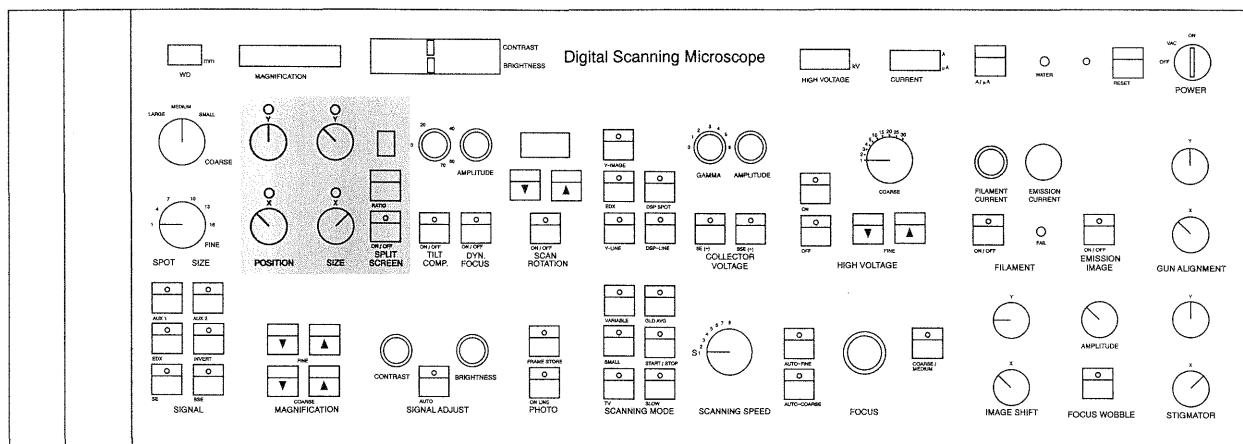
This mode is called with the key **Y-MOD IMAGE**.

- One frame is scanned and the scanning process stopped.

The image is cleared, and 48 equidistant lines in the image field are scanned in Y-modulation. The Y-modulated signals are loaded in the frame store.

- Photographic recording of the image with **Frame Store**.
- Return to normal scanning mode by restart of scanning with **START** or selection of another scanning time.

4.15.5 Split Screen



With the Split Screen function a field on the specimen is scanned twice, and the resulting two fields are displayed in the upper and lower halves of the screen.

In this mode the user can switch between different signal sources, for comparison of the two displays (e.g., SE and BSE image in picture # 39).

Switching the function on and off

- The Split Screen function is activated with the key **ON/OFF** (4); the yellow LED in the key is on.
- Pressing the key **ON/OFF** (4) again switches off the Split Screen function; the yellow LED goes out.

 The Split Screen function is not operative in TV mode and may be called up only from Slow Scan mode.

Splitting of the image

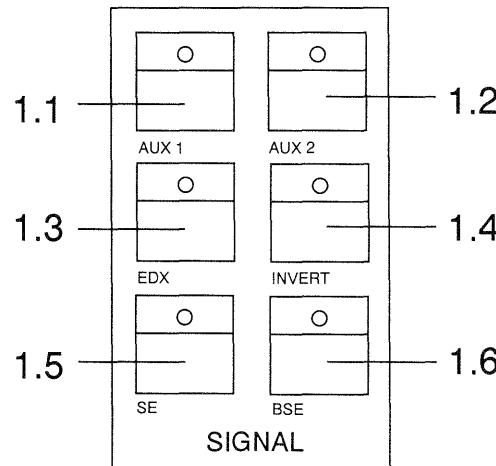
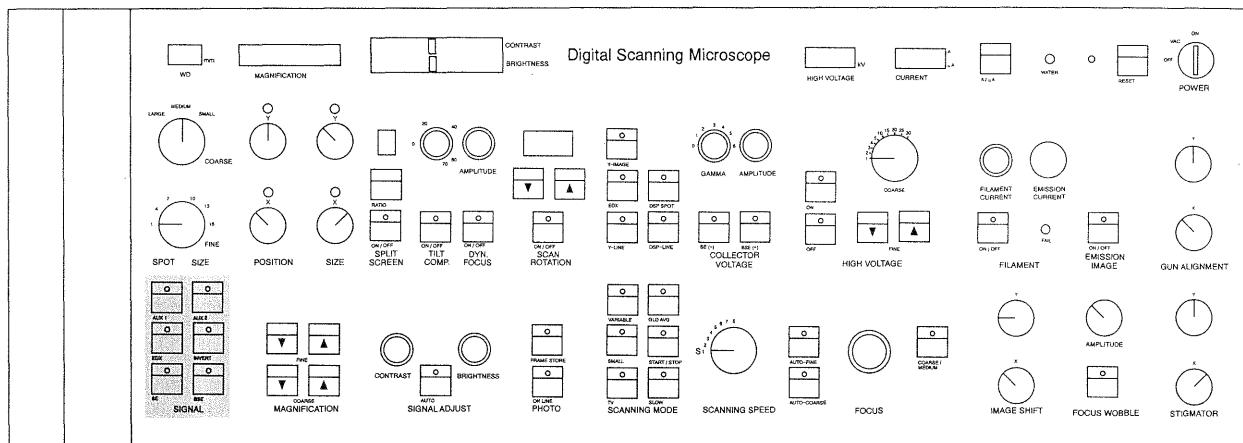
The image field on the monitor is divided horizontally. Both images have the full number of lines and pixels. In Frame Store mode each partial image will have 256 lines and 512 pixels in each line. Both images are scanned in on-line mode with 1024 lines or 2048 pixels in each line.

Scanning on the specimen

An image field on the specimen is scanned, which corresponds to the normal width of the image and half the normal image height. This field is displayed twice on the monitor. The signal sources are changed with each image change depending on the adjustment.

When changing from normal image to split screen, the center of the normal image corresponds to the centers of the upper and lower image; the height of the images is halved. This allows a specimen feature to be centered in normal mode; it remains centered after change to split screen.

Selection of the signal source



- The signal sources are selected with the keys **SIGNAL SELECT** on the front plate of the DSM 960 A. The user can make combinations of his choice.

SE (1.5) for the signal from the secondary electron detector
BSE (1.6) for the signal from the backscattered electron detector (accessory)
EDX (1.3) for the signal from the EDX system (accessory) and for Area Mapping
AUX1 (1.1) and
AUX2 (1.2) for the signals from the two auxiliary inputs

If a signal source is activated the LED in the key is on.

The detectors used for imaging may be entered in the user field of data field or directly in the image.

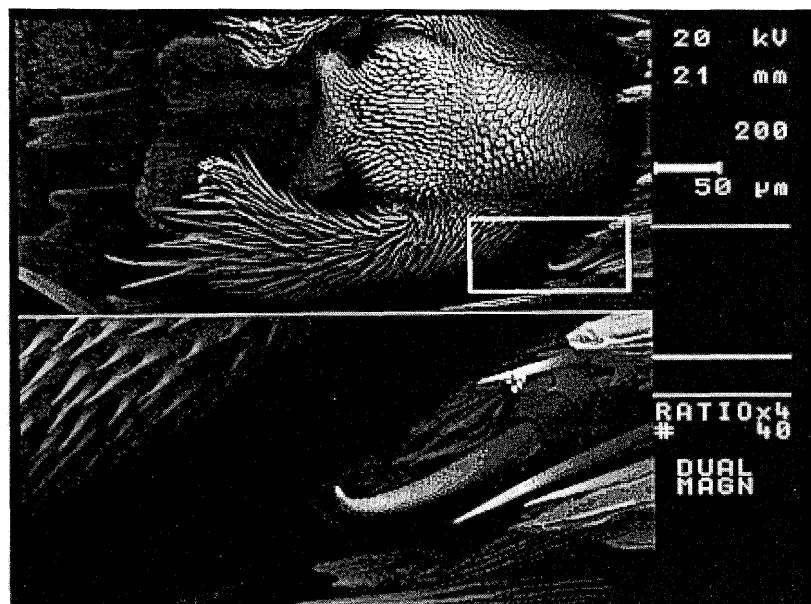
The key **INVERT** (1.4) acts on both images.

4.15.6 Dual Magnification

With this function a section of the upper partial image is displayed enlarged in the lower partial image.

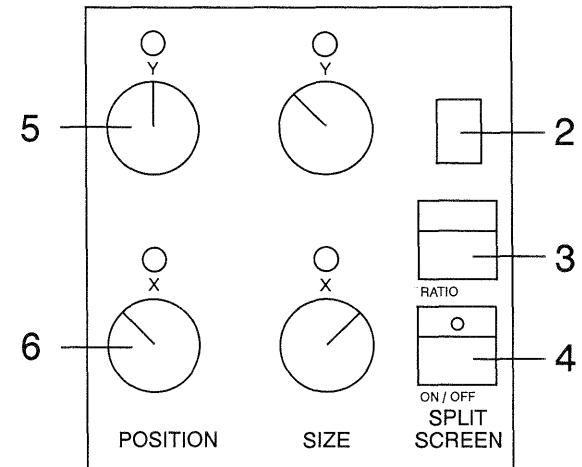
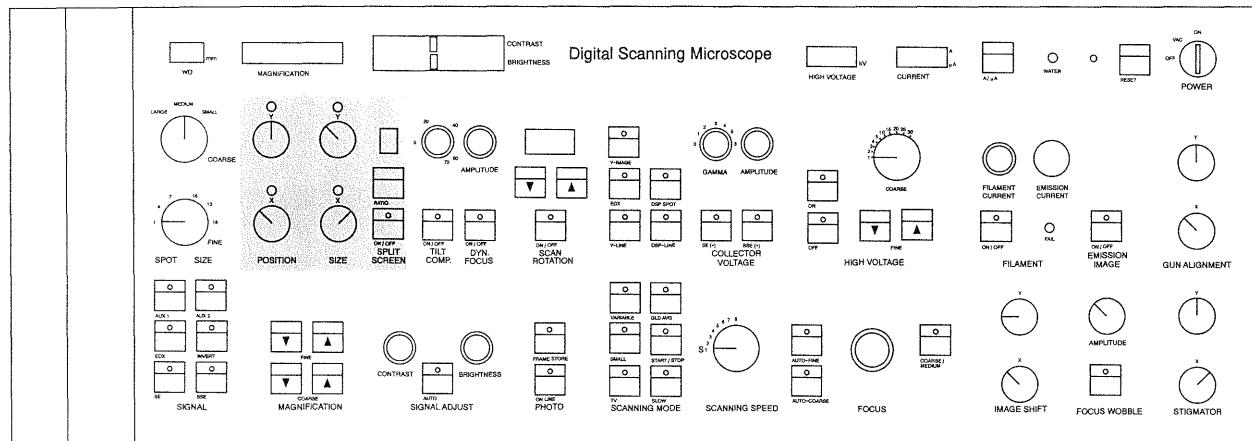
The magnification factors are 2x, 4x and 8x.

The section is adjustable.



Switching the function on and off

- Switch on split screen with **ON/OFF** (4).
- The ratio of magnification between upper and lower image is displayed on **display** (2) and variable in the steps x1, x2, x4, x8 with the key **RATIO** (3).
- The step is displayed in the data field above the photo number (e.g. **RATIO x4**).



Adjusting the image field

If the ratio is greater than x1 a rectangle is overlaid on the upper image field, which corresponds to the lower image field.

The size of the image field is changed in accordance with the magnification ratio.

With the potentiometer **POS X** (6) the image field in the upper image is moved horizontally, and vertically with **POS Y** (5).



Special notes

Change between the different signal sources is also possible in Dual Magnification mode. The Split Screen function is a special function of the Dual Magnification function with the ratio x1, and what was said there also applies to this function.

4.15.7 Scan Rotation

Mechanical rotation with the specimen stage

All stages of the DSM 960 A can be mechanically rotated through 360° relative to the scanning field.

Using this type of rotation a specimen can be observed under different angles, especially if it is tilted, because the axis of rotation is tilted with the specimen.

The specimen rotates relative to the detector so that the specimen "illumination" in the image field comes always from the same direction, e.g. the upper left.

Electrical rotation with the Scan Rotation

With the Scan Rotation the frame is turned on the specimen, i.e., the specimen "illumination" is rotated together with the specimen.

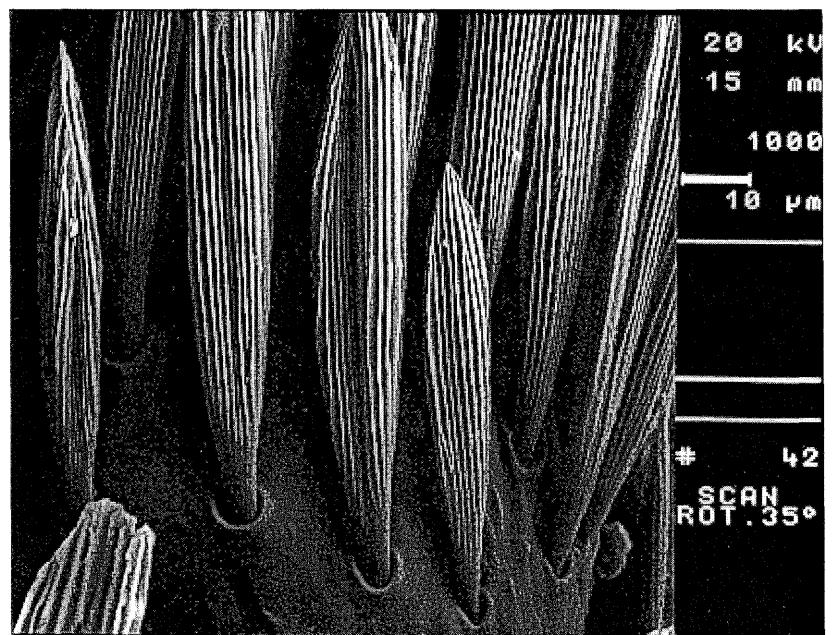
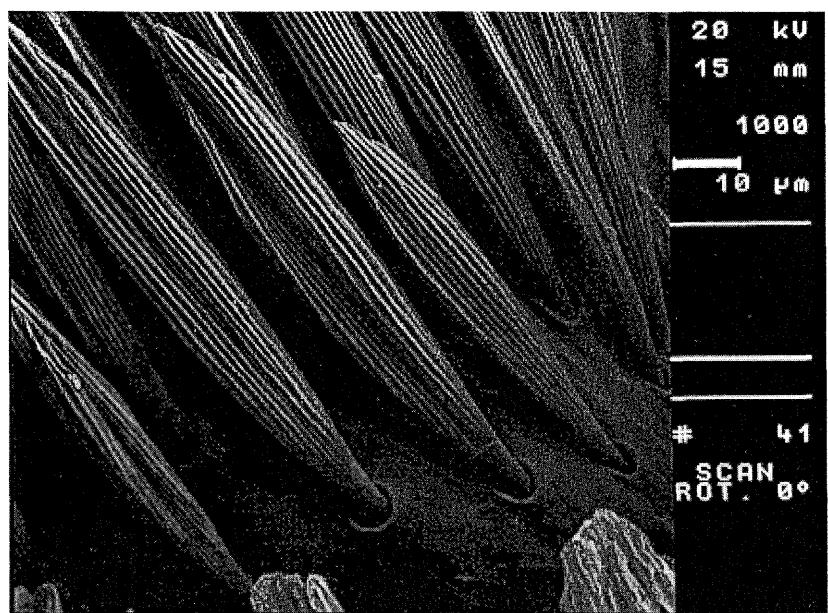
The axis of the scan rotation always coincides with the electron-optical axis, so that tilts of the specimen do not influence the rotation.

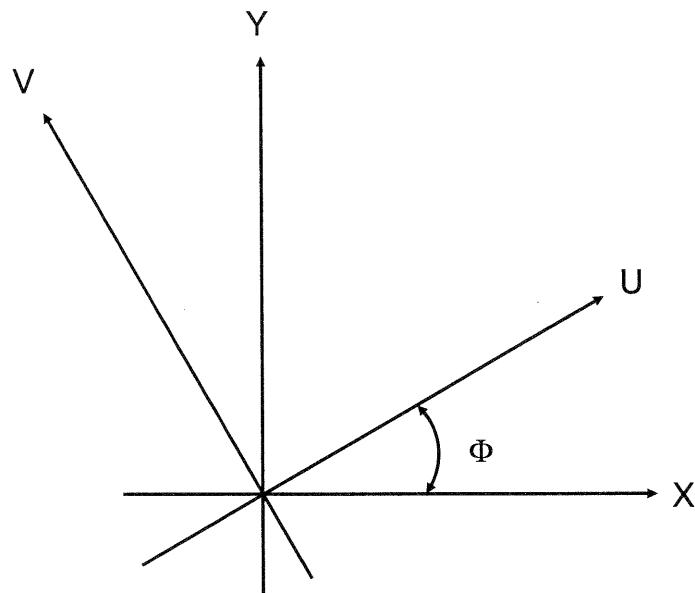
With the electrical scan rotation the edges of the frame are adjusted on the specimen, e.g., for better representation. More important is the possible adjustment of the line scan and the measuring system for any direction without mechanical rotation, especially since the mechanical adjustment becomes the more critical the higher the magnification.

Adjustment of the working distance in an SEM turns the frame because of the magnetic field of the objective lens.

The Scan Rotation compensates this rotation, which is important for the Dynamic Focus for long working distances.

For stereo image pairs the tilt axis of the stages can be adjusted vertically instead of horizontally, which is otherwise impossible with the mechanical tilt.



Circuit diagram

Scan rotation turns the frame on the specimen electronically, which results in rotation of the specimen image in opposite direction on the monitor or the photo tube.

The circuit transforms a right-angled coordinate system X/Y into a right-angled coordinate system U/V which is turned through the angle Φ , according to these equations:

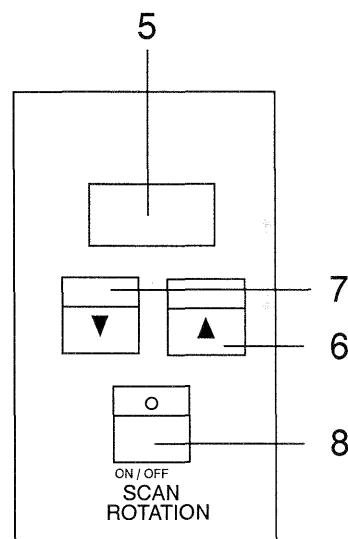
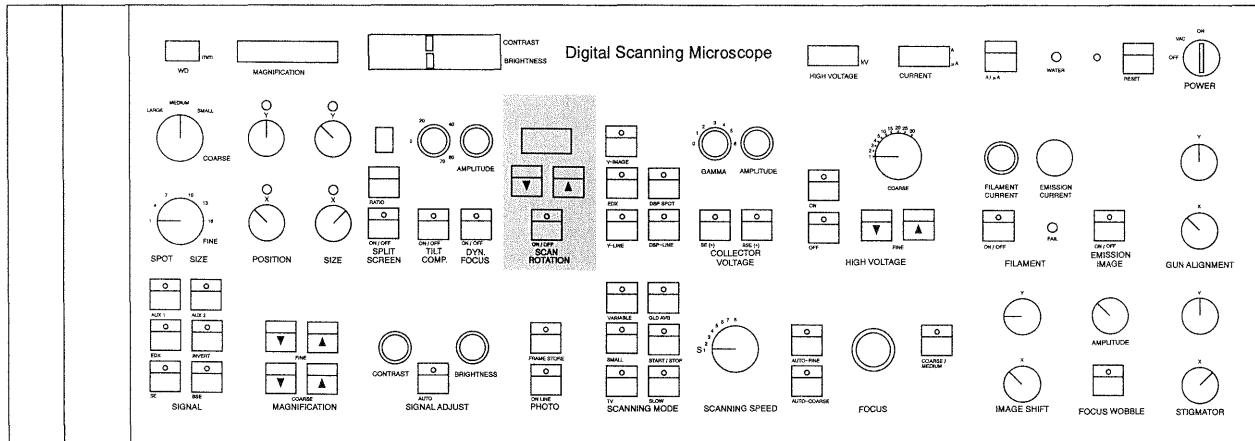
$$U = X \cos \Phi - Y \sin \Phi$$

$$V = X \sin \Phi + Y \cos \Phi$$

Both coordinate systems have the same origin in the center point of the frame.

The goniometric functions are digitally generated and graded in degrees. After the transformation of X/Y into U/V the deflecting amplifiers for the electron beam are driven by the deflecting voltages U/V.

Switch-ON/OFF



- The key **SCAN ROTATION ON/OFF** (8) switches scan rotation on. The yellow LED in the key lights.
 - Pushing the key again switches the scan rotation off; the LED goes out.

Adjusting the angle of rotation

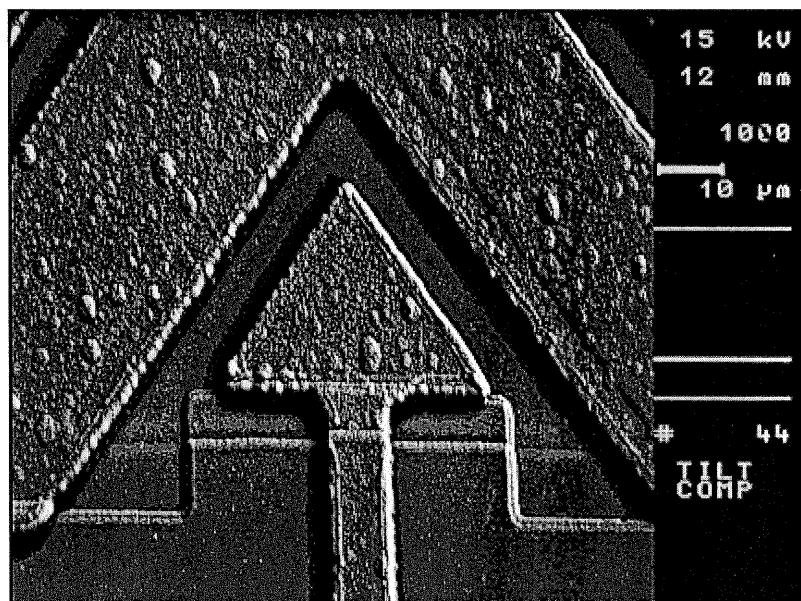
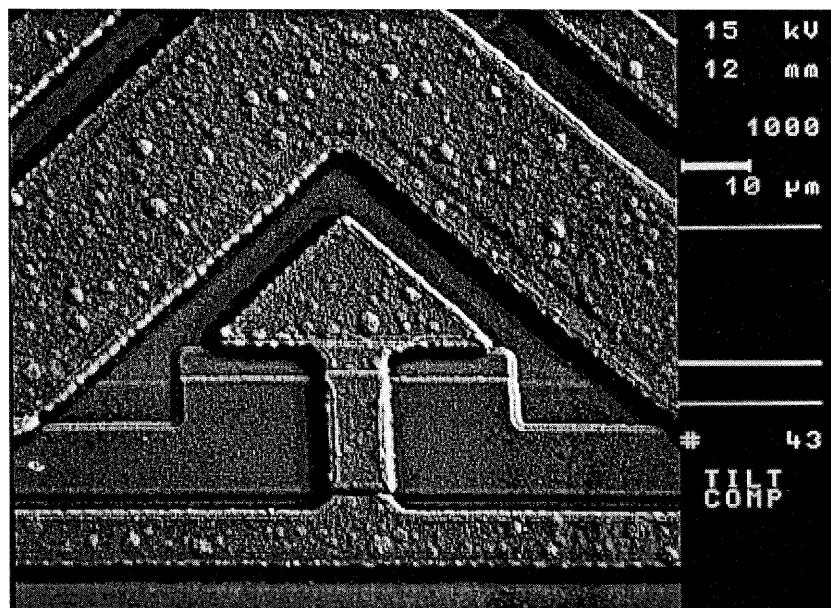
- The angle of rotation is adjusted with keys ▼ (7) for clockwise rotation and ▲ (6) for anticlockwise rotation. **ANGLE** (5) displays the angle of rotation in degrees from 0 to 359.
 - Shortly pushing key ▼ (7) or ▲ (6) advances the rotation by 1°; holding down the key means automatic repetition.

Switching the scan rotation OFF and ON again adjusts the same angle of rotation as before switch-OFF.

 - Instrument reset or switch-OFF of the electronics sets the angle of rotation to zero degree.

Scan rotation is also operational in **SPLIT SCREEN** mode.

4.15.8 Tilt Correction

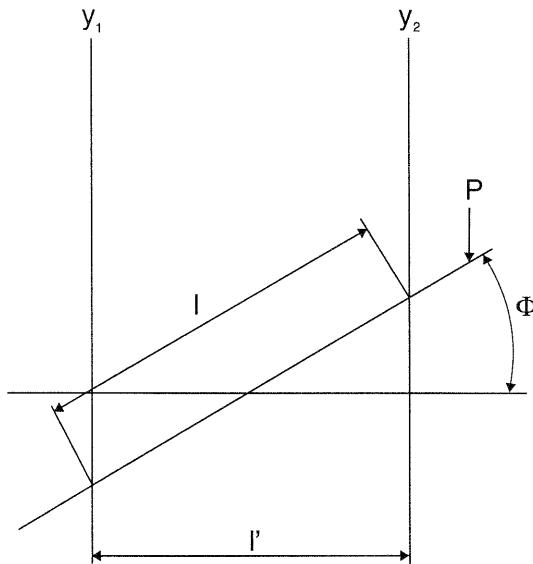


All specimen details are shown as projections on the monitor as well as on the photograph.

Tilted surfaces are displayed foreshortened in the direction of tilt compared to normal observation.

This foreshortening can be corrected when the scan normal to the tilt axis is shortened on the specimen stretching the image in this direction on the monitor and on the photograph giving a correction if properly adjusted. This only can be achieved with absolutely flat specimens e.g. polished sections.

Principle

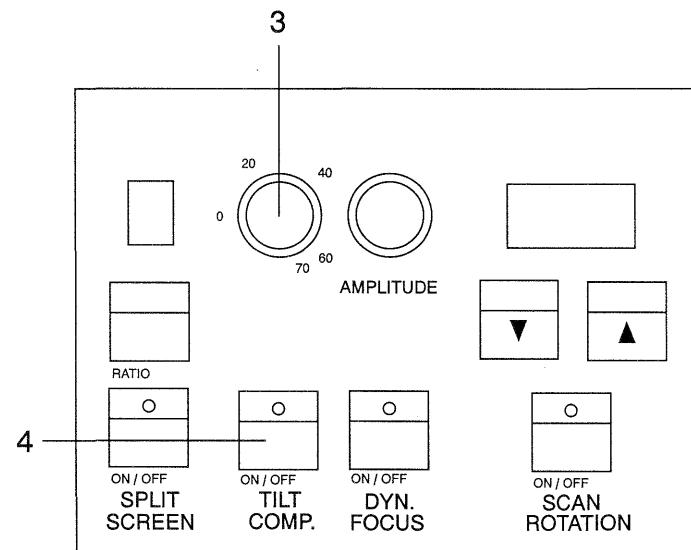
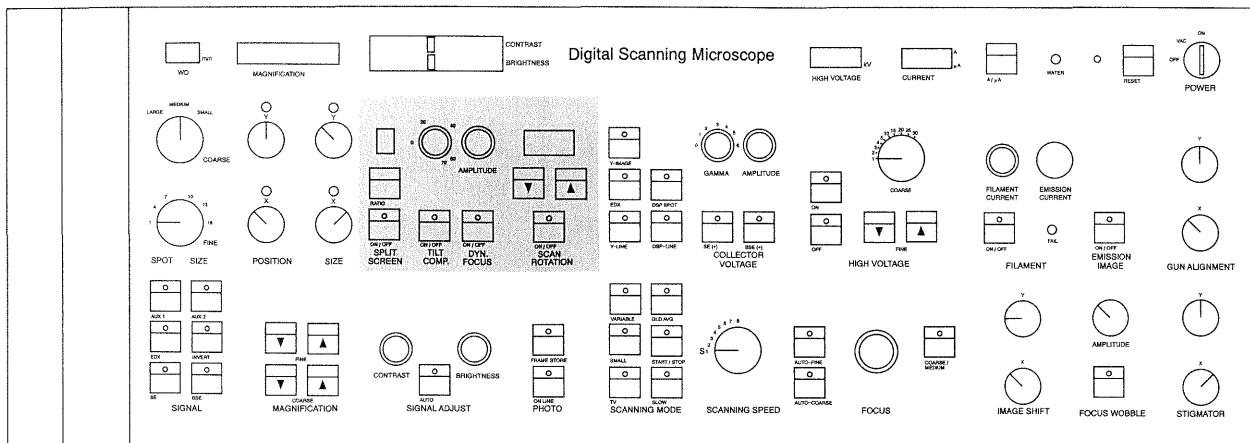


If the electron beam moves on the specimen P from Y₁ to Y₂ it covers the distance l. If the specimen is tilted from horizontal position, and the angle is Φ , the projection of the length l, that is l', is displayed on the monitor. The specimen is foreshortened by the factor

$$\frac{l'}{l} = k = \cos \Phi$$

Foreshortening the frame on the specimen by this factor creates again the original length l on the monitor. The field is foreshortened by an adjustable attenuation of the Y amplitude of the deflection current.

The Tilt-Correction is effective in the Y direction, i.e. the image is vertically rectified on the screen. The tilt direction must, therefore, run along the Y axis, the tilt axis of the specimen surface along the X axis respectively.



Limitations

Electronic scan rotation is unsuited for adjustment of the specimen tilt direction to the Y axis.

The tilt correction will more strongly distort steps or other elevations in the specimen.
The correction will be successful only if the specimens are perfectly flat.

The tilt correction only works in Slow Scan mode.

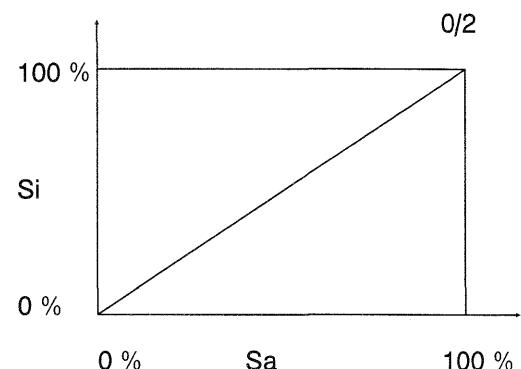
4.16 Special contrast settings (Gamma)

- The contrast rendition may be changed with the switch **GAMMA**.

The input values for brightness and contrast should not be overmodulated to prevent wrong contrast rendition on the screen. This is especially important in manual mode.

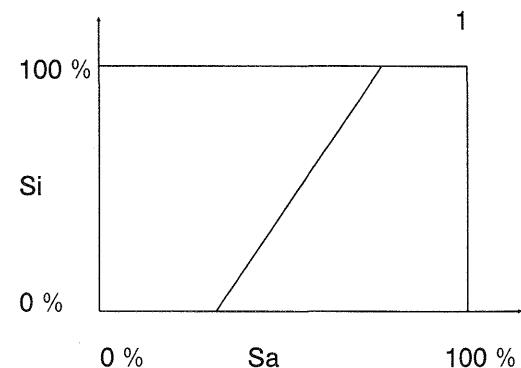
4.16.1 Linear gamma

The transfer function is linear in **switch position 0** (turned fully anticlockwise); the input signal Si on the circuit corresponds exactly to the output signal Sa. The same applies to **switch position 2**.



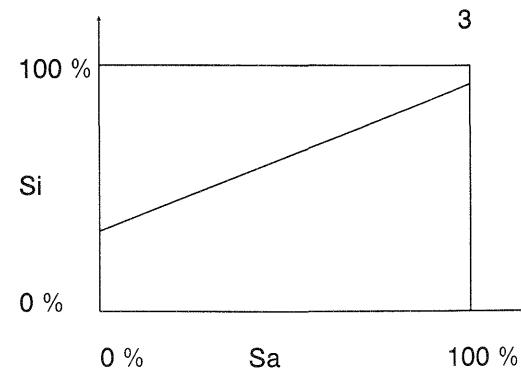
4.16.2 Contrast reduction

The contrast is 50% reduced in **switch position 1**. 100 % contrast at the input signal result in 50 % contrast at the output signal.



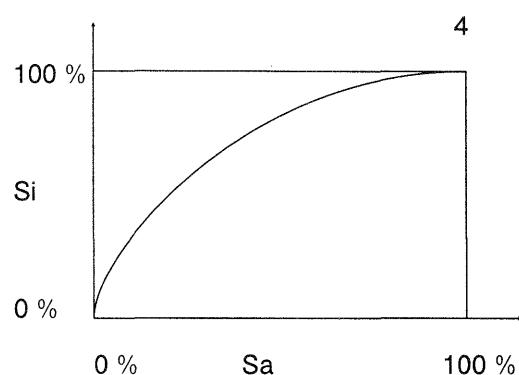
4.16.3 Contrast expansion

The contrast is increased by the factor 2 in **switch position 3**. 50% of the input signal result in 100% contrast at the output.



4.16.4 Gamma < 1

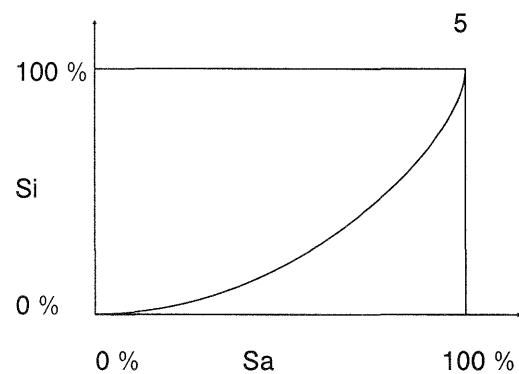
In **switch position 4** bright signal parts are highly amplified and darken ones damped.



4.16.5 Gamma > 1

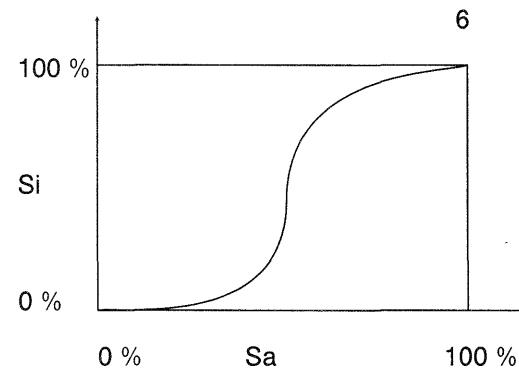
In **switch position 5** the situation is opposite to 4.16.4.

Bright signal parts are damped and dark signal parts are amplified.

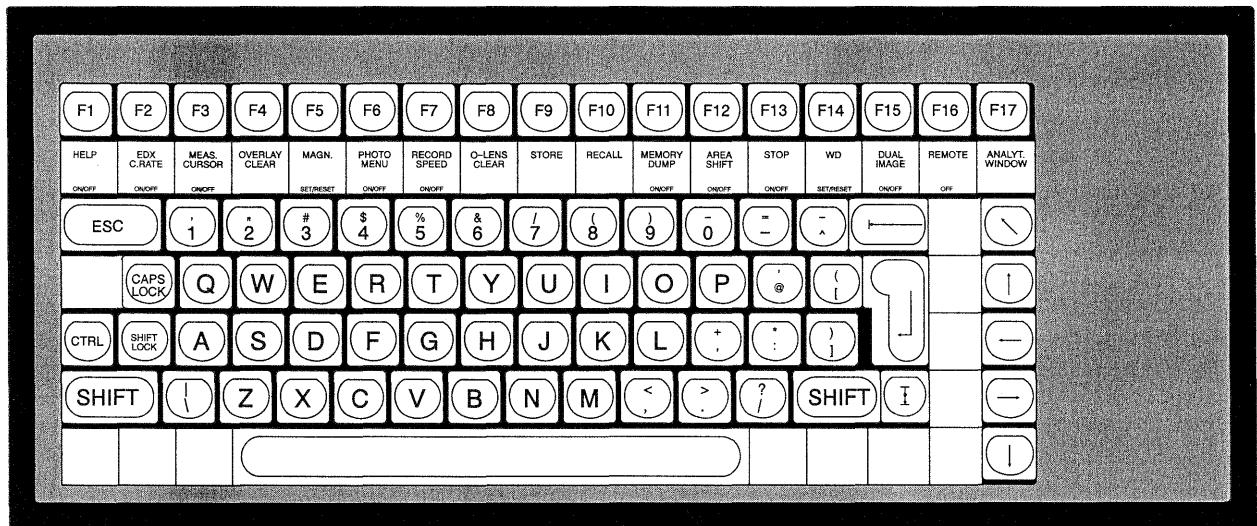


4.16.6 S-correction

In **switch position 6** the signal levels in the bright and dark areas are expanded, and the medium-gray regions damped.



4.17 Special keyboard functions



In addition to the functions activated by the control elements, switches and potentiometers some functions are activated from the keyboard.

These include rarely used, freely programmable functions, functions for further options, and text input.

Some functions have been described above and are mentioned here only with reference to the relevant chapter.

4.17.1 Function keys

Special functions are assigned to some of the keys F1 to F17 in the top row of the keyboard. The function is described by labels. The key **SHIFT LOCK** should not be activated (red lamp in the key off!).

HELP (F1)

- HELP MENU** field is displayed on the screen which lists the special functions and the corresponding keys described hereafter.
- Reset to initial status by pressing **F1** again.

EDX COUNT RATE (F2)

- This key calls the EDX MENU to adjust parameters for mapping and concentration profiles.

MEAS. CURSOR (F3)

- It switches on the measuring system if this accessory is installed.

OVERLAY CLEAR (F4)

- It clears all entries in the overlay. Marks like cross, line, or field for reduced raster entered in the overlay will clear existing text.

MAGN. SET/RESET (F5)

- Switches between actual magnification and the magnification from the menu.

PHOTO MENU (F6)

- Calls up the photo menu.
For a full description of the function see 4.13.3.

RECORD SPEED (F7)

- With this key the record speed for on-line photography is adjusted. For a full description see 4.13.2.

O-LENS CLEAR (F8)

- Pressing the key starts hysteresis compensation of the final lens improving constant focus.

The monitor displays: Please wait, clearing final lens.

STORE (F9) (with stage motorization accessory)

- The coordinates of the stage are stored, 120 positions can be stored.

RECALL (F10) (with stage motorization accessory)

- With RECALL the stage positions for one out of the 120 fields can be recalled and the stage is moved to this position.

MEMORY DUMP (F11) (with stage motorization accessory)

- A menu is called showing which fields in the coordinate storage are empty and which fields are occupied.

AREA SHIFT (F12) (with stage motorization accessory)

- Switches on the X-Y shift of the stage. Shift stage for frame width or frame height with cursor keys.

STOP (F13) (with stage motorization accessory)

- Stops the moving stage immediately and disables the track ball. Pressing the key again enables the track ball.

WD SET/RESET (F14)

- Switches between the actual working distance and the working distance programmed in the menu.

DUAL IMAGE (F15) (if accessory is installed)

- The upper half of the screen is stored. Operation is continued on the lower half.
The new parameters are displayed in the data field.

REMOTE (F16) (if accessory is installed)

- The remote control of an external computer via the remote control interface accessory can be terminated.

ANALYT. WINDOW (F17)

- Switches on a small window which can be adjusted with **POS X/Y**. Window size is 1/4 of the minimum variable reduced raster.
Used to analyse small areas still showing an image compared to SPOT-MODE.

4.17.2 Control keys ESC and CTRL

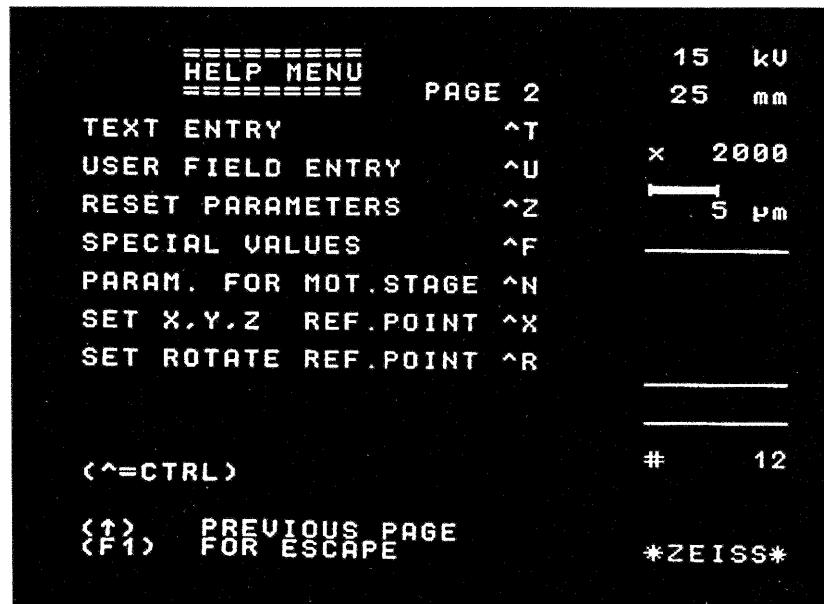
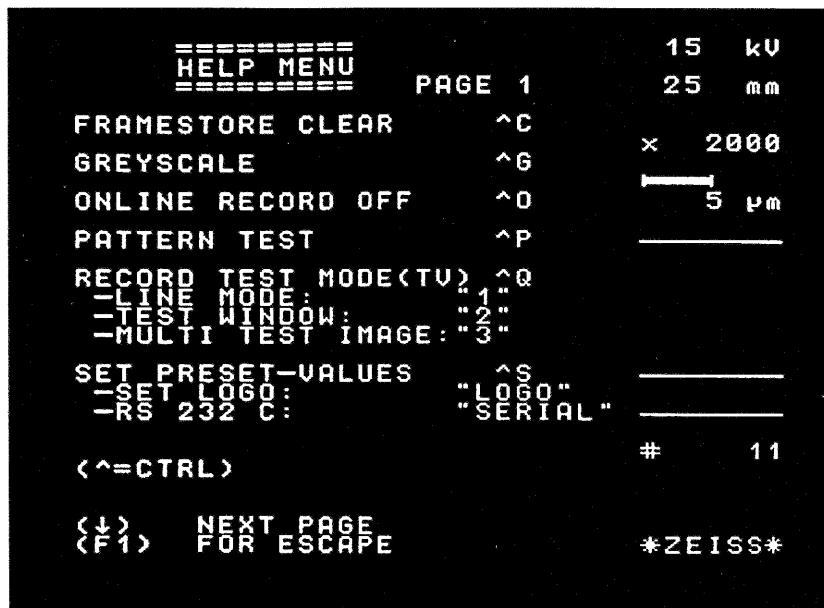
ESC

- ESC (ESCAPE) is used to escape from an adjusted mode and to switch off writing in data field and text field.
- Escape from the text entry mode with CTRL T or CTRL U with **ESC**.

CTRL

CTRL (CONTROL) is used to start a control command.

- CTRL O** (**CTRL** and **O**), for example, breaks off on-line photography (see 4.13.2).

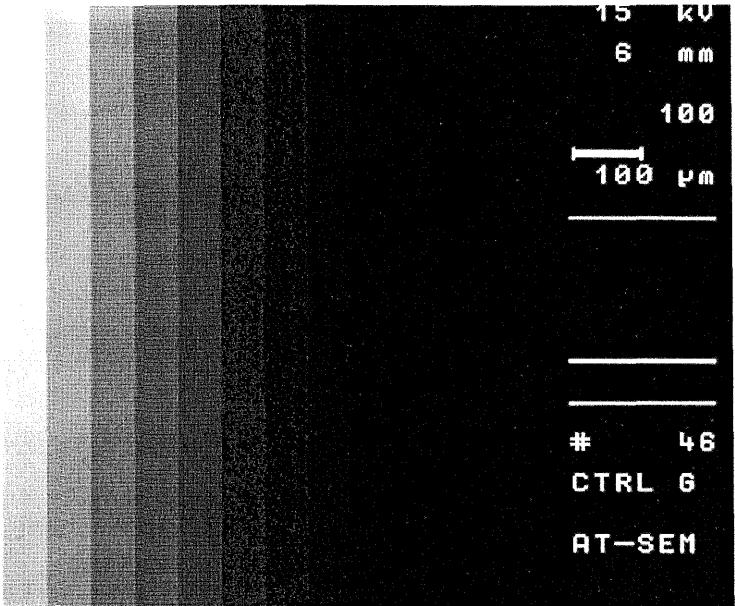


4.17.3 Text keys

Text keys used as control keys

CTRL C

- clears the frame store and sets it to medium gray.



CTRL G

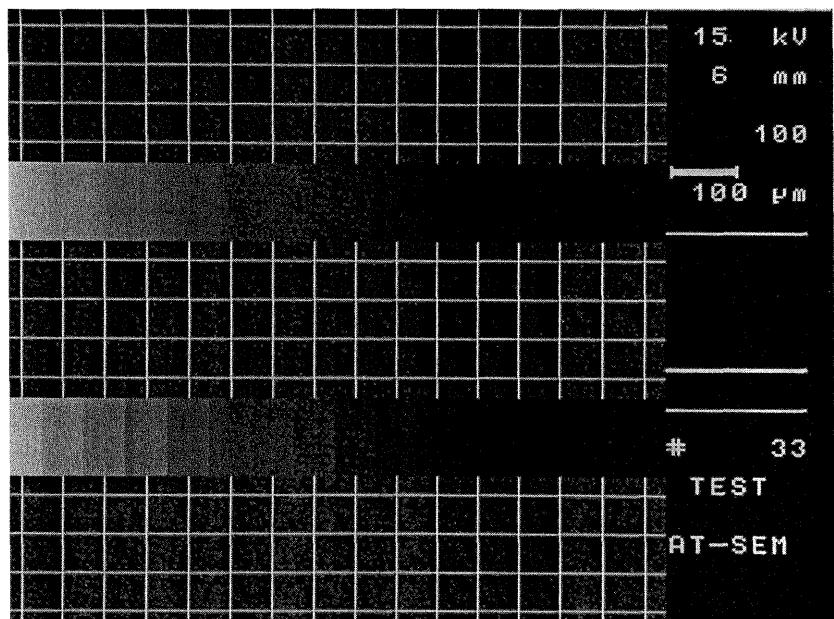
- produces a gray wedge. Starting a scan leads back to normal imaging.

CTRL O

- Terminates ON-LINE record scan (see 4.13.2).

CTRL P

- activates the display of a test pattern on the screen. Its use for the calibration of new film material is described in detail under 4.13.3. Return to normal video mode by the start of scanning mode.



CTRL Q

- Switches on the focusing raster on the recording CRT ref. to 4.13.4)

CTRL Q 1

- LINE-MODE
(CTRL Q 2: TEST-WINDOW; CTRL Q 3: MULTI-TEST-IMAGE/for service purpose)

CTRL S

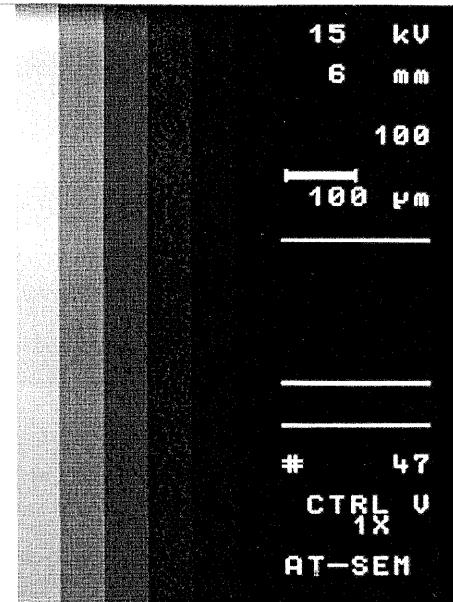
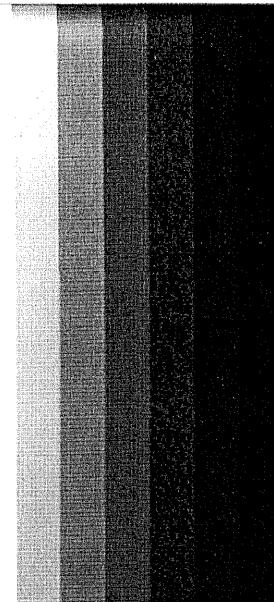
- activates the serial interface and the logo input.

CTRL T

- activates text input in the image field.
Switch-off with **ESC**.

CTRL U

- switches on entries in the user lines of the data field. The text keys then act as input keys. Switch-off with **ESC**.

**CTRL V**

- (Video Store Test): used to test the frame store. Under certain conditions it may be used for subsequent contrast manipulation of the frame store image.

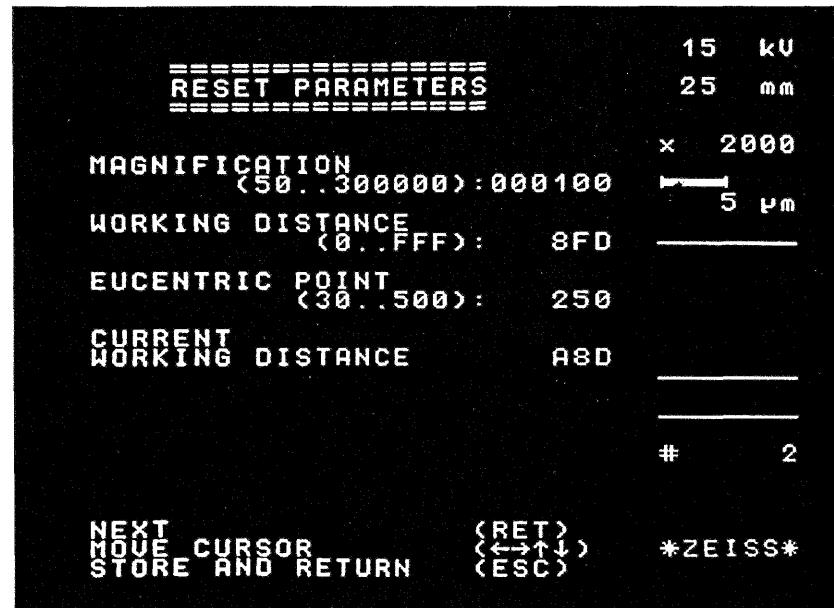
Optically, the contrast of the preceding image is doubled with simultaneous convolution.

The doubling may be carried out 8times until the original status of the image is attained. Make sure that the full frame has passed through before you activate the key **CTRL V** again, because otherwise the correct assignment is interrupted.

If you switch 8 times or load a new image you will return to normal video mode.

CTRL N; CTRL X; CTRL R MOT-STAGE PARAMETERS

- These control keys can only be used with the stage motorization accessory.

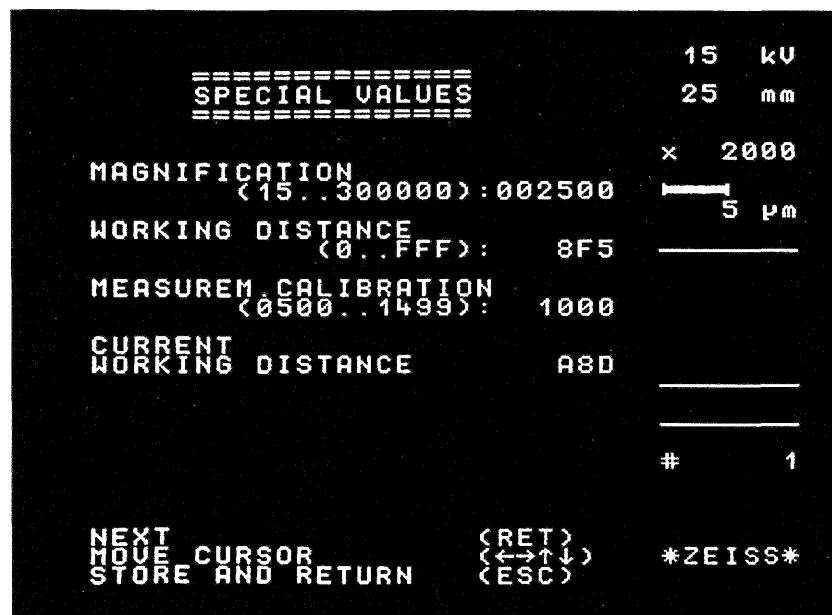
CTRL Z

RESET- Parameters

- When the DSM 960 A is switched on or a **RESET** is executed the cold start parameters are adjusted. These parameters can be selected in the RESET menu.
- Put in the magnification in a range of 50 to 300 000 to which the DSM 960 A shall be set. (Input is 6 digits long).
- The working distance can also be programmed. Here the input is in hexadecimal code. For easy input leave the menu with ESC. Now adjust the desired working distance with the **FOCUS** control. Reentry the menu with **CTRL Z** and transfer the working distance displayed (current working distance) into the input line (working distance).

At a cold start the photo unit is automatically calibrated indicated with the two LEDs in the frame store and the on-line keys flashing. This is independent of other operating modes.

CTLR F



Special values

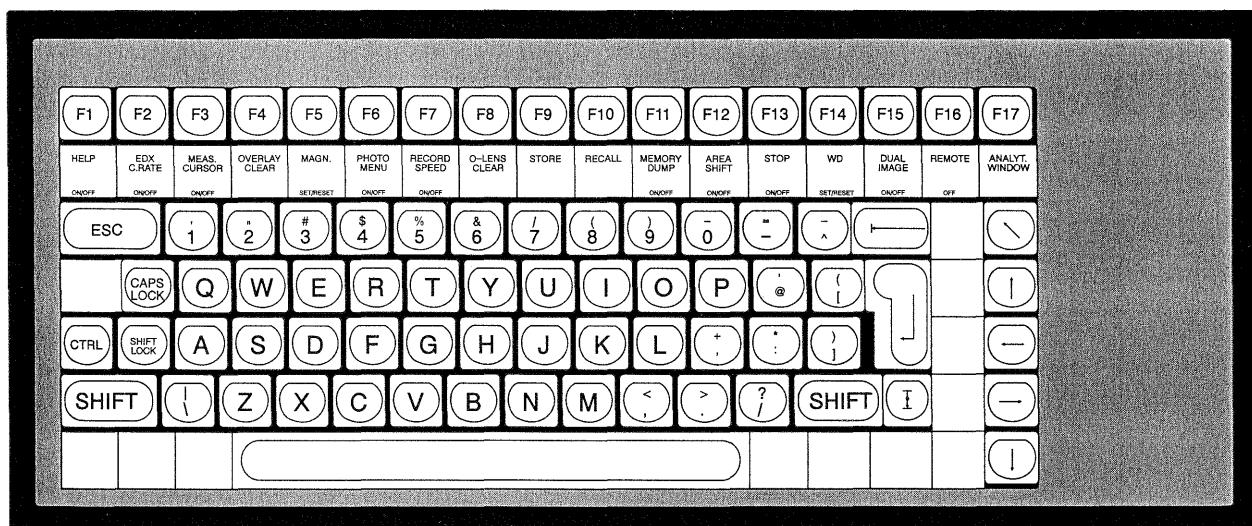
Reference values for magnification, working distance and the calibration value for the measuring bars can be input here which can be called with function key F5 and F9.

- Function key F5** toggles between the actual magnification and the reference magnification. Pressing the key again returns to the original magnification.
- Function key F14** toggles between actual working distance and reference working distance from the menu. Input of the reference working distance is done by copying from the line labelled "current working distance".

When the distance measuring accessory is installed, the read out of the bar distance can be calibrated to absolute values. Calibration factor is valid from minimal 0.500 to 1.499.

- Leave the menu with **ESC**.

4.17.4 Text entry



Text keys as text input keys

The keys act as normal text keys if a text input mode is activated. Change between capital and lower case letters with the **SHIFT** key.

All keys have repeat function; if a key is held down the corresponding character is repeatedly written on the screen after a short delay.

- The cursor (flashing square) marks the place for the next character.
- It is moved with the cursor keys in the corresponding direction $\uparrow \downarrow \rightarrow \leftarrow$ without changing the text.
- Direct return to first position of the writing field to the upper left with **↖**.

32 characters on 32 lines can be written on the image field.

Switch-ON Text entry mode

- Activate the Text entry mode in the image field with **CTRL T**.

Switch-OFF of Text entry mode

- Escape the write mode with **ESC** and return to normal operating mode of the DSM 960 A.

Number of characters

The function of the keyboard keys are described below.

The key designation is listed in the left column. If a key carries two signs the lower case is shown to the left, the upper case to the right. The next column lists the characters which are displayed on the monitor when the key is pushed, and printed for normal mode.

No character means that the key is ineffective.

Normal mode means that neither **SHIFT**, **CAPS LOCK** nor **CTRL** are pushed.

The characters which are set with **SHIFT** or **SHIFT LOCK** are shown in the next column, those obtainable with **CAPS-LOCK** in the fourth column.

The last column lists the characters which can be displayed with **CTRL**.

Letters

Upper and lower-case letters can be displayed by the combinations listed below. The following applies to the functions activated with **CTRL**.

- | | |
|--------------|------------------------------------|
| LEFT | = cursor to the left |
| DOWN | = cursor down |
| UP | = cursor up |
| RIGHT | = cursor to the right |
| CR | = carriage return
and line feed |
| CLEAR | = text cleared |

KEY	NORMAL	SHIFT	CAPS	CTRL	15 kV	25 mm
A	a		A	A		
B	b		B	B	x 100	
C	c		C	C		
D	d		D	D		100 μm
E	e		E	E		
F	f		F	F		
G	g		G	G		
H	h		H	LEFT		
I	i		I	I		
J	j		J	DOWN	# 4	
K	k		K	UP		
L	l		L	RIGHT		
M	m		M	LINE	*ZEISS*	

KEY	NORMAL	SHIFT	CAPS	CTRL	15 kV	25 mm
N	n		N	N		
O	o		O	O	x 100	
P	p		P	P		
Q	q		Q	Q	100 μm	
R	r		R	R		
S	s		S	S		
T	t		T	T		
U	u		U	U		
V	v		V	V		
W	w		W	W	# 22	
X	x		X	X		
Y	y		Y	Y		
Z	z		Z	CLEAR	*ZEISS*	

Numerals and special characters

- | | |
|------------------------------|-------------------------------------|
| HOME | = cursor to the left upper corner |
| ESC | = escape the text mode |
| DOWN | = cursor down |
| ENTER | = CR= carriage return and line feed |
| ESC and CTRL [| are equivalent. |

KEY	NORMAL	SHIFT	CAPS	CTRL	15 kV	25 mm
1 !	1	!	1	1		
2 "	2	"	2	2	x 100	
3 #	3	#	3	3		
4 \$	4	\$	4	4	100 μm	
5 %	5	%	5	5		
6 &	6	&	6	6		
7 .	7	.	7	7		
8 <	8	<	8	8		
9 >	9	>	9	9		
0 -	0	-	0	-	# 8	
- =	-	=	-	-		
^ -	^	-	^	HOME		

KEY	NORMAL	SHIFT	CAPS	CTRL	15	kV
I←				BACKSP.	25	mm
\	\		\		x 100	
. <	.	<	.	.	100	μm
. >	.	>	.	.		
/ ?	/ ?	/ ?	/ ?			
↓	DOWN	DOWN	DOWN	DOWN		
: +	:	+	:	:		
: *	:	*	:	:		
] >]	>]			
@ `	@	`	@		#	10
[<	[<	[ESC		
ENTER	LINE	LINE	LINE	LINE	*ZEISS*	
ESC	ESC	ESC	ESC	ESC		

Function and cursor keys

With the function keys special characters are displayed on the monitor such as arrows in all four directions, μ-sign, exponential and Angstrom signs etc.

Text mode is left with **ESC**.

KEY	NORMAL	SHIFT	CAPS	CTRL	15	kV
F1	↑	~	↑	↑	25	mm
F2	←	°	←	←	x 2000	
F3	→		→	→		
F4	↓		↓	↓	5	μm
F5	⇒		⇒	⇒		
F6	π		π	π		
F7	ρ		ρ	ρ		
F8	■■■		■■■	■■■		
F9	z		z	z		
F10	ʒ		ʒ	ʒ	#	10
F11	ø		ø	ø		
F12	-1		-1	-1		
F13	À		À	À	*ZEISS*	

KEY	NORMAL	SHIFT	CAPS	CTRL	15	kV
F14	À		À	À	25	mm
F15	ä		ä	ä	x 2000	
F16	ö		ö	ö		
F17	Ü		Ü	Ü	5	μm
↖	HOME	HOME	HOME	HOME		
↑	UP	UP	UP	UP		
←	LEFT	LEFT	LEFT	LEFT		
→	RIGHT	RIGHT	RIGHT	RIGHT		
↓	DOWN	DOWN	DOWN	DOWN		
ESC	LEAVE	TEXT	MODE		#	14
						ZEISS

Miscellaneous

The Text Entry system uses a binary plane (overlay) which is separated from the gray image store. Frames and measuring marks are overlaid in this plane. A text can be deleted by sweeping with a frame or a measuring mark. The text entry should be made directly before documentation.

Remember, however, that the space bar or characters can overwrite frame or measuring mark lines.

Text entry can be made during frame acquisition when reading into the frame store. Text entry must be made before frame-store or on-line photography.

4.18 Adjusting the monitor screen to the room light

It is not necessary to darken the room because of the integrated frame store.

For critical adjustments the room light should be dimmed.

- The monitor screen is adjustable to the room light pattern which is called up from the keyboard with **CTRL P**.
- With the controls of the monitor adjust the contrast and brightness of the test image so that it is correctly represented, i.e. all gray levels on the monitor clearly visible and resolved.

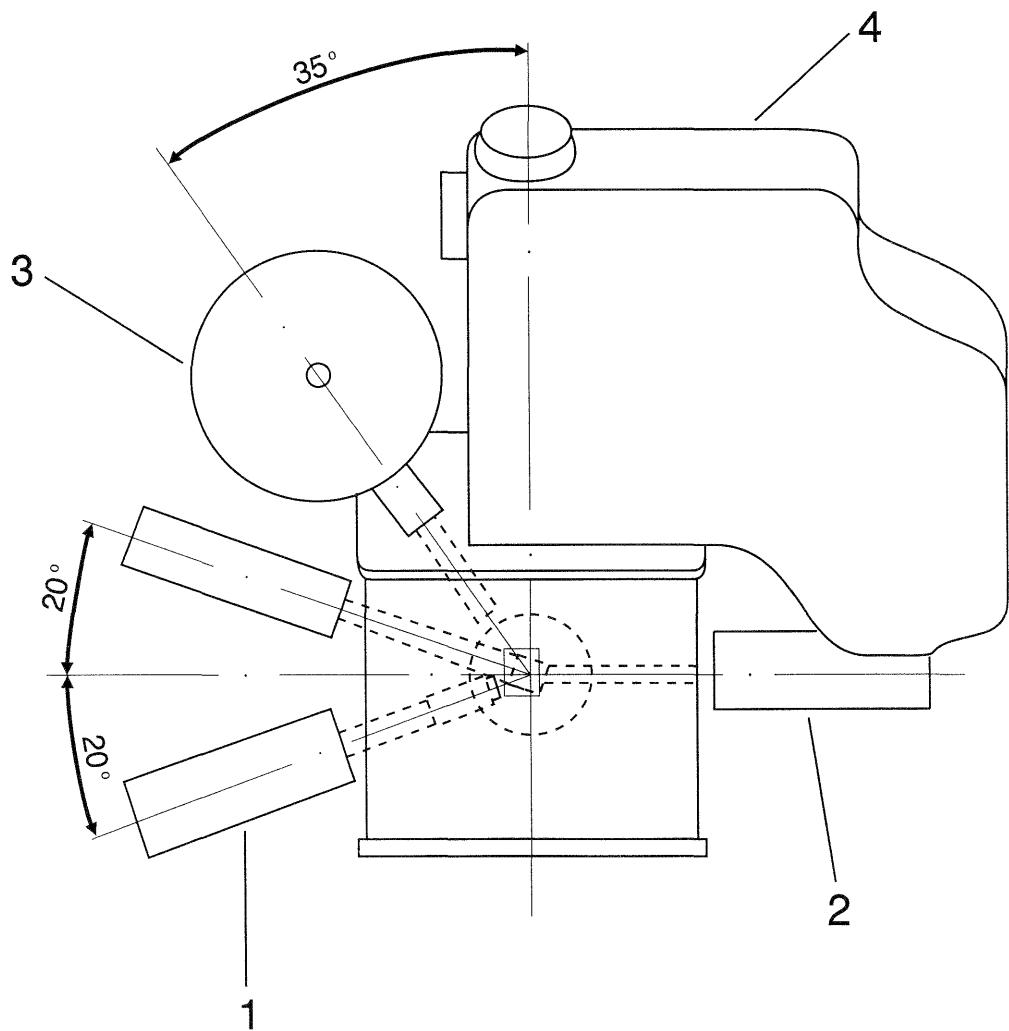


The correct adjustment of the monitor is especially important for the judgement of the image if image contrast and brightness are manually adjusted.

4.19 Connection of attachments

There are different groups of attachments:

- Detectors which are mounted on the chamber.
- Electronic attachments which are integrated in the instrument; the corresponding operating elements are already provided on the front panel.
- Electronic attachments which are integrated in the housing and have front panels of their own.
- Software attachments which require exchange of the program modules.



4.19.1 Mounting on the chamber

The chamber is provided with ports for the mounting of detectors:

A port for the BSE-detector (1)

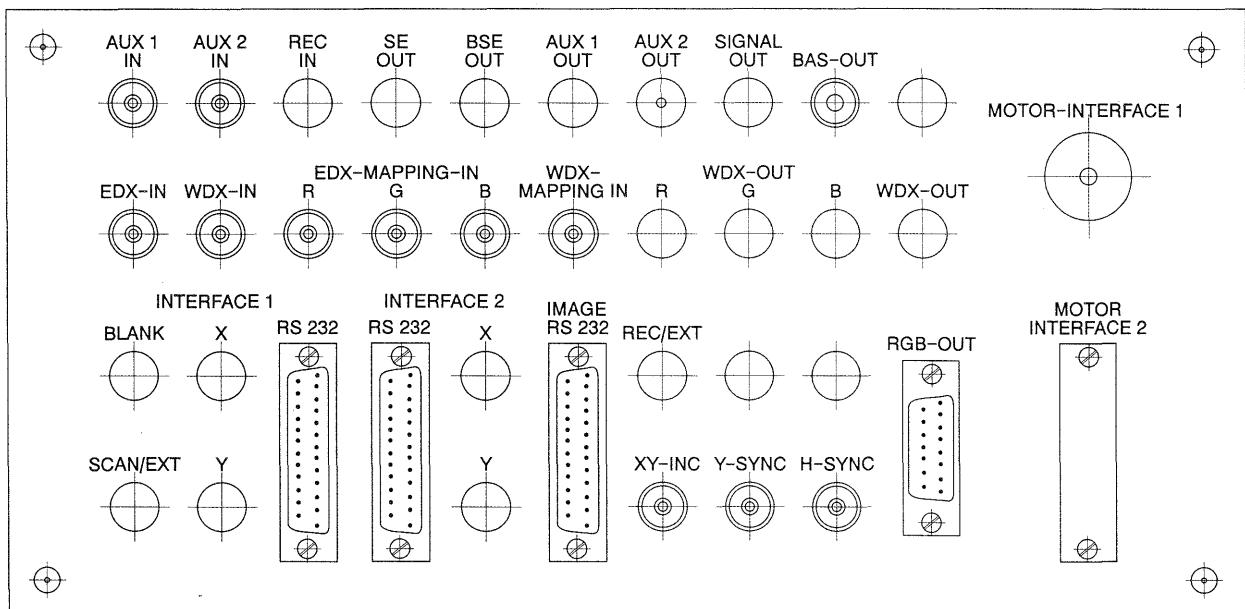
CL-detector (2)

With a special back plate is used an EDX-detector (3) and a WDX-spectrometer (4) can be mounted together.

Mounting a TV-camera for chamber viewing with illumination is possible.
Electrical feed throughs can be mounted if necessary.

4.19.2 Mounting facilities on the back panel

The back panel of the electronic console is prepared for plug-in connections of attachments incorporated in the instrument

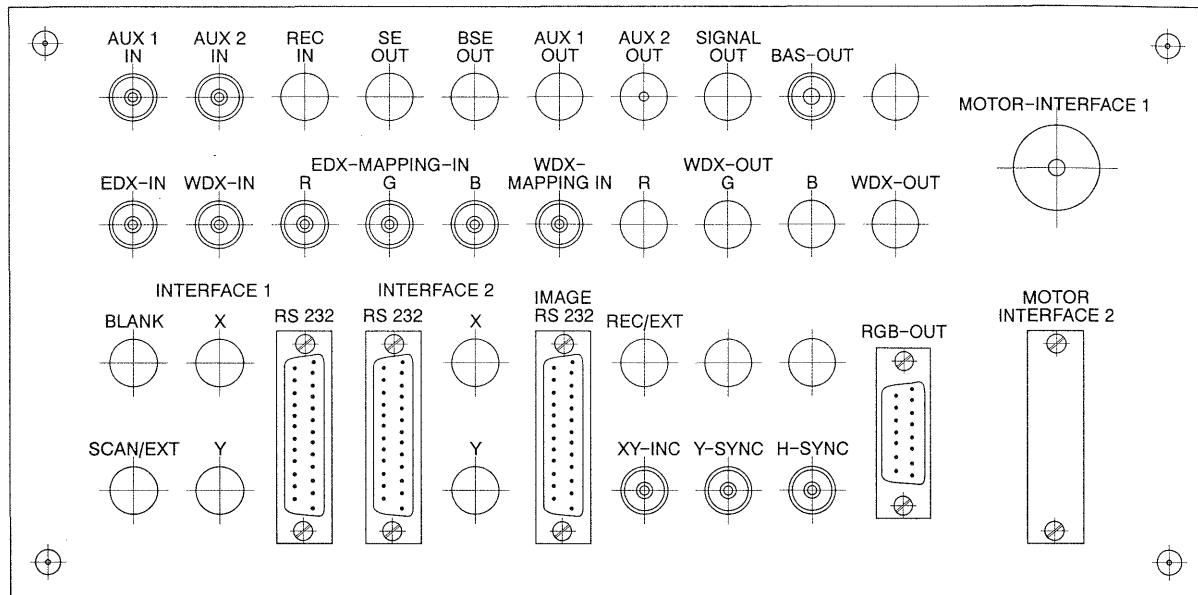


Pin assignment of outlets for accessories are described in the accessory manuals.

Following connections are mounted in the base instrument:

AUX2 IN: Signal input. Impedances see diagram
BNC connector
Signal level is -0.5 V for black and + 0.5 V for white.

BAS OUT: Signal output. Impedances see diagram.
TV-output according to CCIR- or NTSC standard without pre- and post-sync. for attachment of external monitors, video recorders etc.
BNC connector
Signal level 0 - 1 V.



The X-ray microanalysis system is connected by normal coaxial cables provided with BNC plugs on the side of the DSM 960 A.

The terminal layout is shown in the drawing:

EDX IN : input for count rate meter of EDX system
(0 to +1V DC)

WDX IN : input for count rate meter of WDX system
(0 to +1V DC)

EDX MAPPING IN for EDX system

R : pulse input for elemental map RED
(TTL level)

G : pulse input for elemental map GREEN
(TTL level)

B : pulse input for elemental map BLUE
(TTL level)

WDX MAPPING IN for WDX system

Can be switched by the menu to R, G or B.

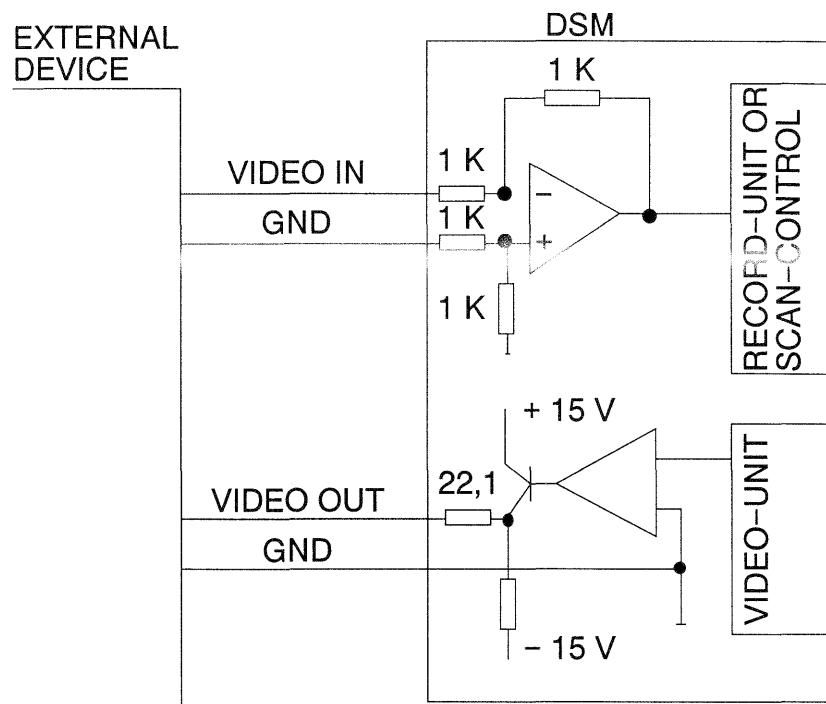
EDX OUT for transfer to other peripherals

Output of pulses for R, G, B for connection of other image analysis systems.

WDX OUT for transfer to other peripherals

Output of pulses for connection of other image analysis systems.

The outputs are only activated if the DSM 960 A is switched to external scanning mode.



X Y INC : Pixel clock of the frame store
 BNC connector
 TTL- level: Polarity selectable on BAS-board (Technical Service!)
 X15 1-2 XY INC
 X15 2-3 XY INC negated

V-Sync : Vertical synchronisation pulse

H-Sync : Horizontal synchronisation pulse
 BNC connector

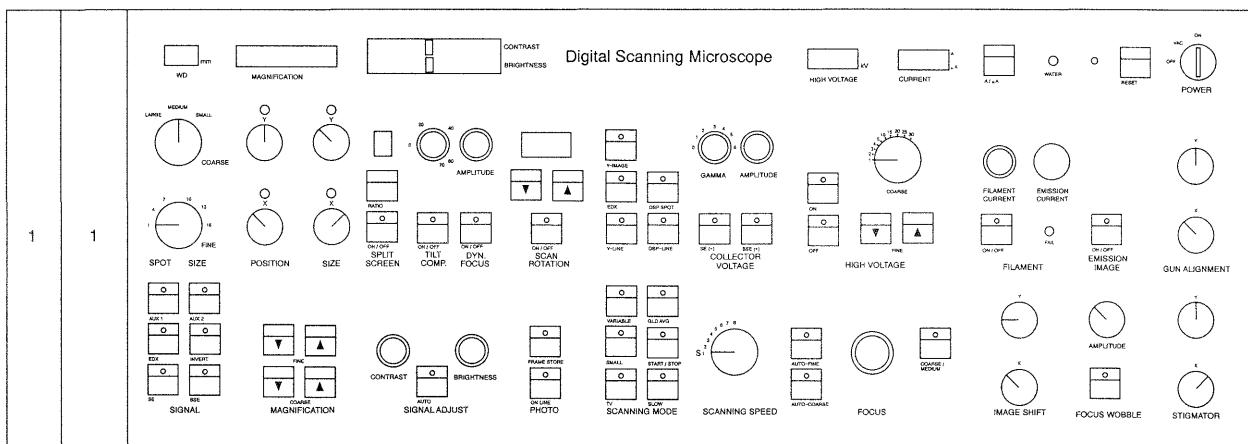
The synchronisation levels and the output modes can be programmed on the BAS board by jumpers (Technical Service!) and adjust the mode of the DSM 960 A:

X 11	X 12	X 13	X 14	
1-2	1-2	5-6	2-3	TV-Slow-Scan-Sync.
2-3	2-3	5-6	2-3	TV Sync.
1-2	1-2	3-4	1-2	TV-Slow-Scan Sync.negated
2-3	2-3	3-4	1-2	TV Sync. negated
			1-2	SV/SH-Sync.



Main outlets for EDX-, WDX-unit and accessory are provided on the power supply.

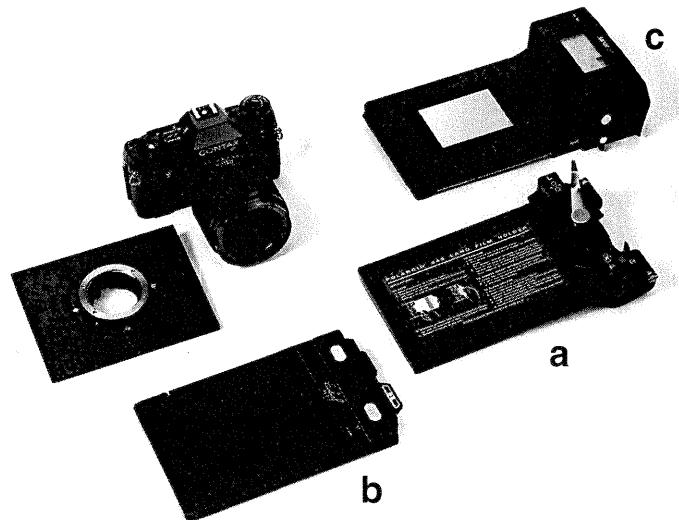
4.19.3 Attachments in the electronic console



Attachments with operating elements are accommodated in the housing in the electronic console, which also contains the control modules for the detectors (BSE and CL).

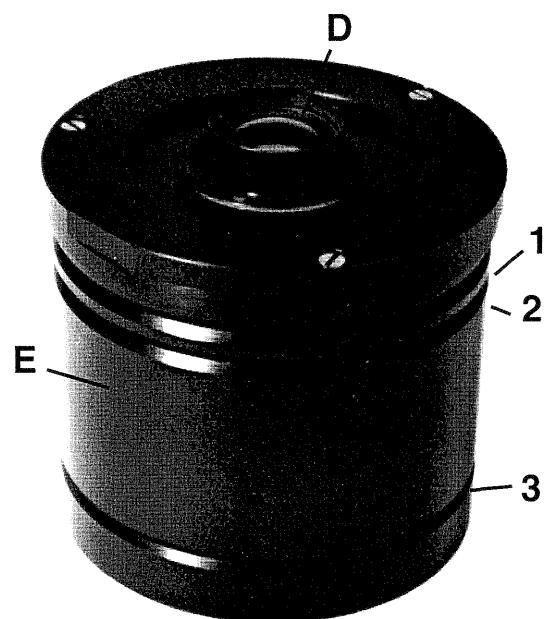
If the room is not sufficient, a separate swivel rack can be installed on the right side of the console (above the photo unit).

4.19.4 Photographic unit



The 4x5" Polaroid back on the photographic unit may be replaced by other cameras or camera backs. If the optical system is not exchanged, as e.g. for the 35 mm camera, it can be shifted to achieve the desired image scale.

- Position 1: 4x5" Polaroid back (standard (a)), full image
- Position 2: 9x12 cm sheet film back (accessory (b)), full image
or 4x5" Polaroid back with reduced image
- Position 3: 120/220 roll film camera (accessory (c)), full image.



For a full description of mounting and adjustment of the photographic attachments, see the relevant instructions.

5. Maintenance and Service

5.1 General

The DSM 960 A should be regularly monitored and checked.

The check should include the

- mechanical,
- electron-optical,
- electrical and
- electronic functions,
- the vacuum system with automatic control and the cooling system,

as well as cleaning and maintenance, to eliminate malfunctions before they become effective.

A service contract should be concluded for the DSM 960 A upon expiration of the warranty period, to guarantee regular service of the instrument by our service specialists.

Maintenance measures are described in this chapter, which the user can carry out himself, and hints given for the exchange of expendable parts, if this is possible with simple tests and auxiliary means.



Warning:

All live parts are covered to protect the user. It is not permitted to remove covers or open the instrument.

Changes and repairs of electrical instruments may only be performed by persons expressly authorized to do so. See also 1.2 Important Information.

Keep the instrument clean and dustfree, especially:

- Table top and chamber area to prevent contamination of specimen and specimen chamber.
- All parts which are in vacuum or inserted in vacuum. Always wear lintfree gloves and use forceps to hold small parts and specimens.
- Do not apply force to adjust precision parts such as stage or aperture holders, to prevent them from being damaged.

5.2 Cleaning methods

5.2.1 Molybdenum apertures

(3mm dia. apertures)

Heavily contaminated apertures should be boiled several minutes in 20% NaOH, rinsed and then boiled in distilled water for approx. 5 minutes. Then bring up aperture to bright red heat in vacuum (better than 5×10^{-4} , vacuum evaporator) on a strip of molybdenum sheet or in a molybdenum boat; avoid overheating because the aperture easily melts on molybdenum.



Allow aperture to cool down well before ventilating the vacuum evaporator (danger of oxidation).

5.2.2 Metal parts

(anode, Wehnelt cylinder, holding ring, aperture holder, cleaning tube, stray electron aperture)

- Clean surfaces tarnished blue, brown or yellow with polishing paste and cotton wad (or Q-tip).
- Wipe off residues of the polishing paste with toluol or acetone, or remove them in an ultrasonic bath.
- Rinse with 100% alcohol.
- The pole pieces must be cleaned only by Technical Service.

5.2.3 Vacuum seals

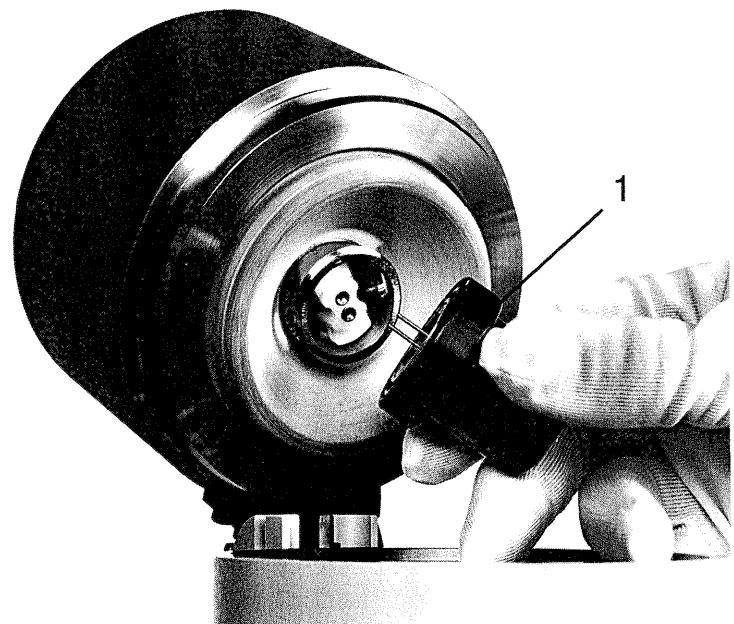


Do **not** loosen vacuum seals with hard or pointed tools; always use a wooden stick.

- Clean seal groove and counter surface with lintfree cloth soaked in alcohol or with lens tissue paper.
- Clean sealing ring in alcohol.
- Lubricate seals with vacuum grease "Apiezon L". Non-moving seals should be provided with a thin grease film or dry-mounted.
- Check seal groove and seal for cleanliness and insert seal.

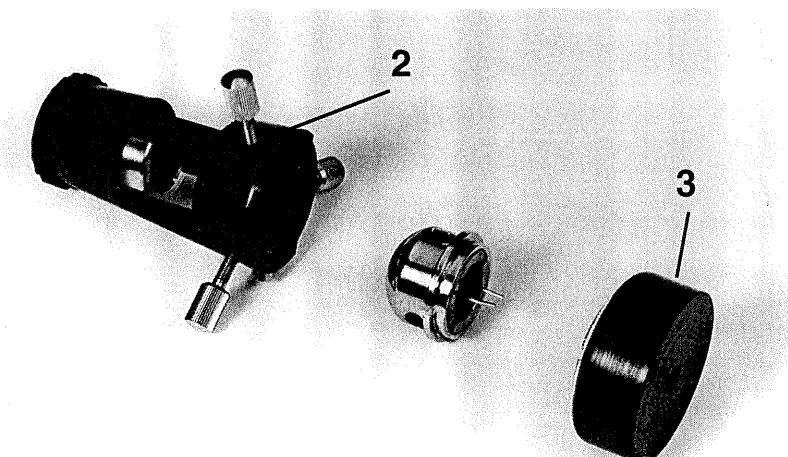
5.3 Filament exchange

The filament needs replacement if no image can be acquired, if the heating current (emission current) display is at zero with heating current power-on, and the red signal lamp **FAIL** lights.



5.3.1 Filament removal

- Ventilate the instrument,
- Remove 3 screws with hex ball driver
- Hinge back electron gun.



- Unscrew holding ring with tool (1).
- Pull off filament with Wehnelt cylinder.



Caution: the Wehnelt cylinder will be hot after long use!

- Insert Wehnelt cylinder in alignment device (2), slacken and unscrew clamping ring with (3).
- Take out defective filament.
- Clean Wehnelt cylinder, Wehnelt aperture, spacer, shim and clamping ring.

5.3.2 Filament assembly and alignment

- Place Wehnelt cylinder in alignment device.



The lateral holes and the alignment screws must be correctly aligned (indices on Wehnelt cylinder and alignment device).

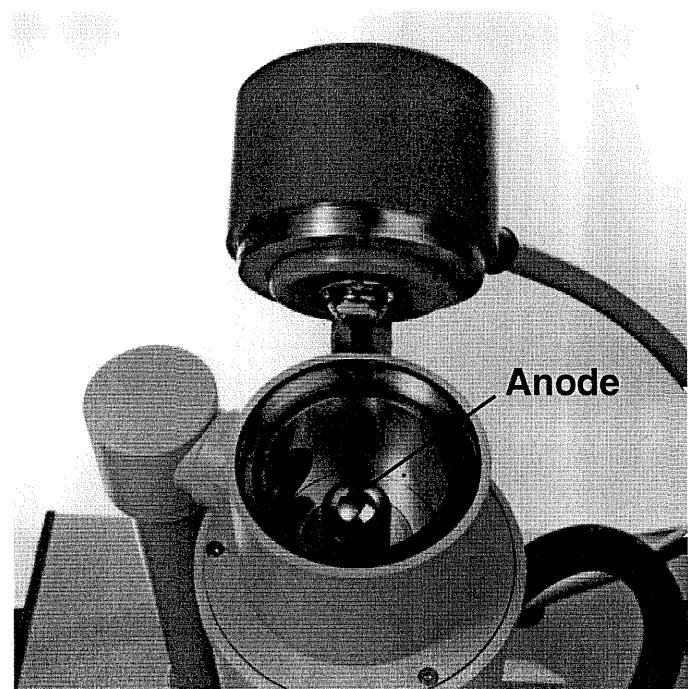
- Screw in alignment screws a few turns to prevent the Wehnelt cylinder from falling out of the alignment device.
- Insert Wehnelt aperture in Wehnelt cylinder.
- Insert spacer and shim.
- Insert new filament and coarsely align ceramic insulator with alignment screws in Wehnelt cylinder. The contact pins must be correctly aligned to the grooves in the Wehnelt cylinder.
- Screw in clamping ring and tighten moderately with device (3).
- Turn about alignment device. For easier centration of the filament it may be placed on a light box together with the rotation device.
- Center the filament tip with the alignment screws through the magnifier in the Wehnelt aperture.
- Tighten clamping ring, control centration.

5.3.3 Filament mounting

- Insert Wehnelt cylinder. The grooves should be correctly aligned.
- Screw on holding ring with tool (1).
- If a replacement cylinder is available, the second holding ring with Wehnelt cylinder and pre-aligned filament may be stored in (1) and closed with a cap.
- Clean Wehnelt cylinder and anode by blowing off dust particles.
- Close electron gun, check for correct seating and cleanliness of sealing ring.
- Evacuate instrument and saturate filament (4.4).

5.4 Anode, liner tube

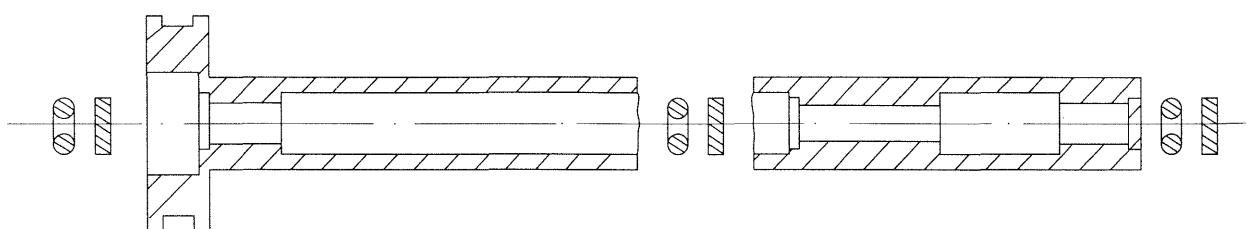
5.4.1 Anode removal



- Unscrew anode (gloves) and clean especially the borehole (5.2.2).

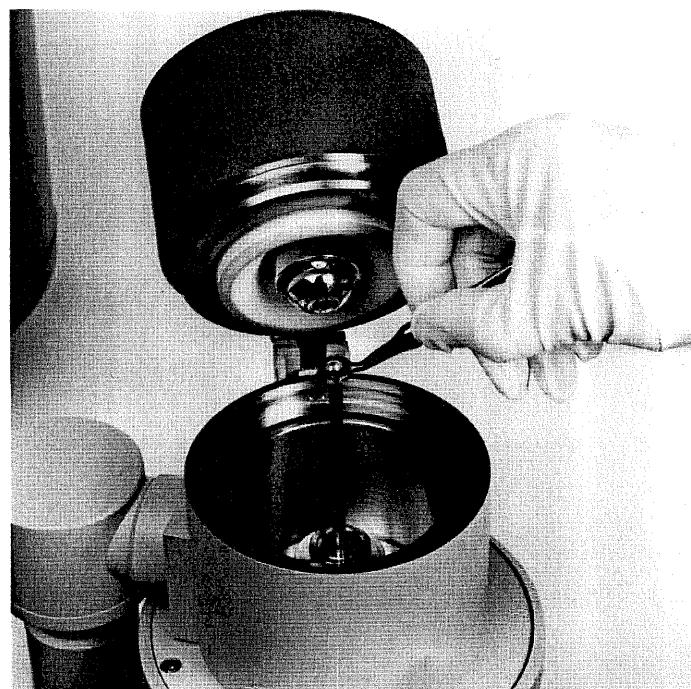
5.4.2 Disassembly of liner tube

- Hold upper rim of liner tube with forceps and pull out. Do not exert lateral force.
- Unscrew lower part.



- Pull out retaining ring of the apertures: press lifter together, insert in retaining ring, release lifter and pull out ring (a groove at the end of the lifter grips the spring and pulls it out).
- Take out apertures.
- Clean apertures and liner tube (5.2.1 and 5.2.2).

5.4.3 Mounting the liner tube



- Insert apertures.



The chamber in the aperture borehole must point away from the beam direction!

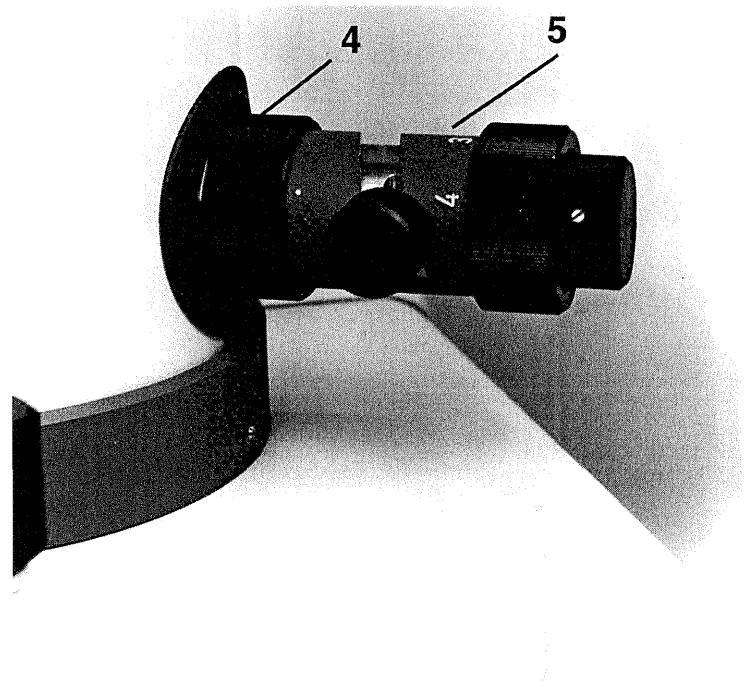
- Grip spring ring with lifter and press it down.
- Screw liner tube together.
- Insert liner tube: hold it exactly vertically and let it slide down, but don't let it drop down.

5.4.4 Anode mounting

- Screw in anode (wear gloves).
- Blow off dust particles on the anode.
- Control seating and cleanliness of sealing ring before closing the electron gun.
- Close electron gun, mount 3 screws with hex ball driver
- Evacuate instrument.

5.5 Assembly and disassembly of final apertures

An increase in astigmatism is often a sign of contaminated apertures.



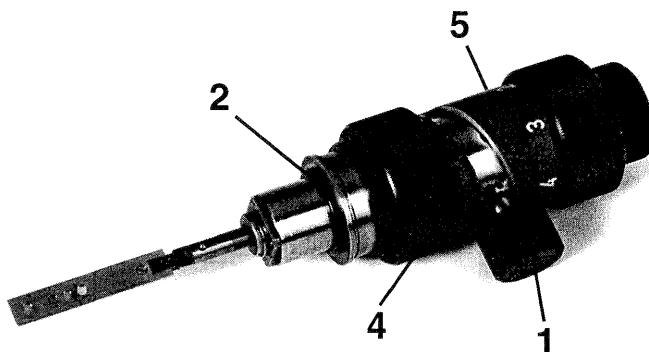
5.5.1 Disassembly of final aperture (5)

- Ventilate instrument.
- Unscrew holding ring (4)
- Pull out final aperture (5).

5.5.2 Aperture exchange

- Press lifter together and insert in spring ring, release and pull out spring ring.
- Take out aperture.
- Clean aperture (5.2.1).
- Clean aperture holder, if necessary (5.2.2).
- The screw holding the aperture holder to the aperture changer is made of a special non-magnetic alloy. Don't loose it! Don't replace with ordinary steel screw otherwise strong astigmatism will occur.
- Insert aperture in aperture holder, make sure that it is correctly oriented!
- Insert spring ring with lifter in borehole of aperture holder, press down spring ring; make sure that it is correctly inserted.
- Press aperture lifter together and take out of spring ring.

5.5.3 Mounting of aperture changer (5)



- Blow off dust particles on aperture.
- Control seating and cleanliness of seal (2).
- Insert aperture changer (5) in column; make sure that guide notch and pin are correctly engaged, centering drive (1) horizontally to the front.
- Secure holding ring (4).
- Evacuate instrument.Align aperture (4.6).

5.6 Scintillator exchange

It needs replacement if the image noise increases.

 It must be exchanged more frequently if you work at high beam currents.

5.6.1 Scintillator removal

- Ventilate the instrument.
- Open the chamber,
- Unscrew the detector flange,
- Unscrew the collector grid with removertool (wear gloves).
- Unscrew scintillator with scintillator changer and take it out.

5.6.2 Scintillator mounting

- Take new scintillator out of container, insert in scintillator changer and screw it on the light guide.
- Carefully blow off dust particles.
- Screw on collector grid.
- Screw on detector flange, check the sealing ring for cleanliness.

5.7 Care of shock absorbing system

If the pressure drops in the air-filled shock absorbers, the mounting plate (for chamber and vacuum system) comes into contact with the frame, and leads to high vibration sensitivity.

 Always check the levelling also when mounting or dismounting accessories on the chamber.

5.7.1 Inflation

- Screw pump hose to the corresponding valve on the back of the column unit and inflate shock absorbers.

5.7.2 Deflation

If the pressure is too high, deflate the shock absorbers by pressing in the central pin of the corresponding valve, and lower the mounting plate.

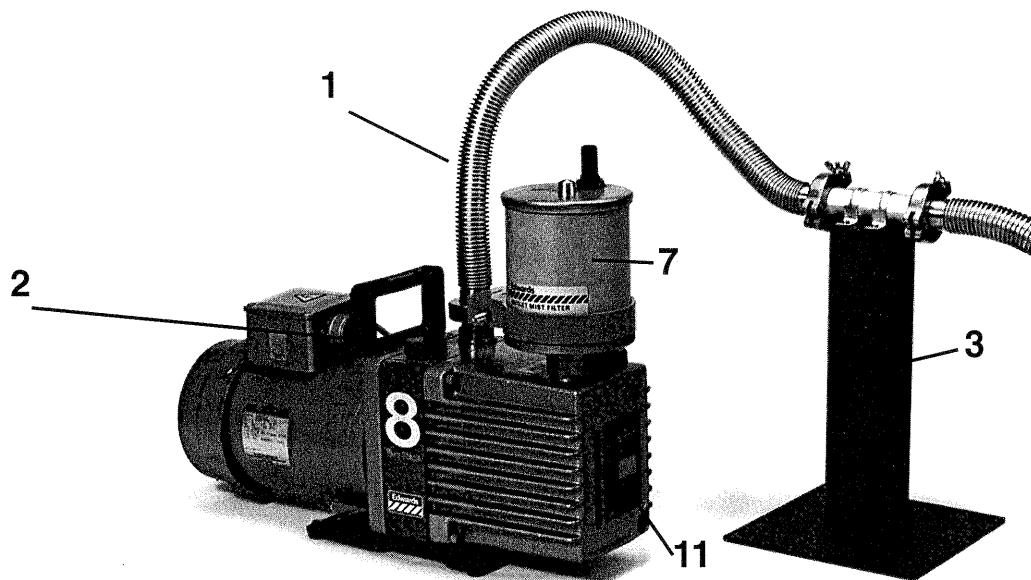
Chamber and column must be movable without hitting each other.

5.7.3 Autolevelling System

This system needs no maintenance. However coarse shocks should be avoided. They might affect performance adversely.

5.8 Maintenance of vacuum system

5.8.1 Rotary pump (Edwards EDR 8)



Gas ballast pumping

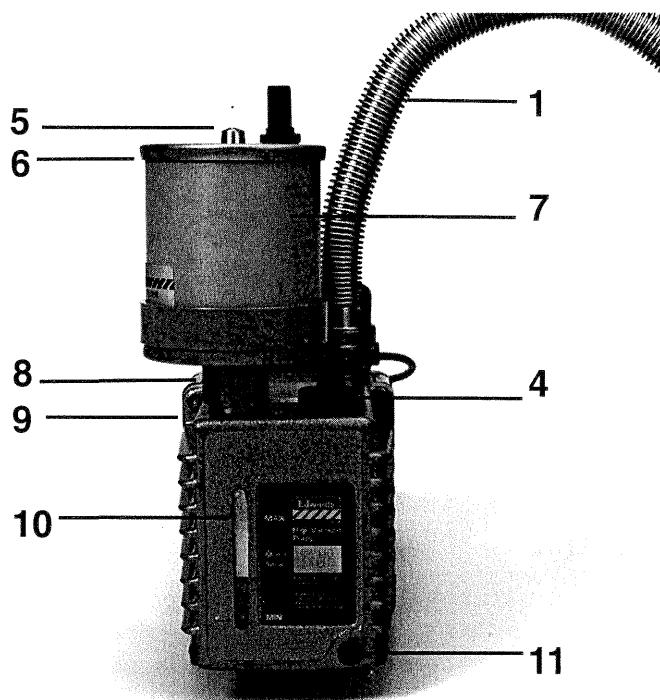
Required if condensable vapors (also water) must be pumped.

- Take off prevacuum tube (1) and close the suction opening.
- Open gas ballast valve (2) by turning anticlockwise.
- Pull the power plug of the pump on the instrument and directly plug in pump.
- Allow pump to run for approx. 30 minutes.
- Close gas ballast valve.
- Plug in instrument plug
- Mount prevacuum tube.

Oil refill

(if oil level in window below half)

- Slacken counter nut (9) and unscrew oil mist filter (7) (if installed).
- Unscrew filling screw (4).
- Refill oil (Edwards No. 15) until the oil level in the window (10) is above half.
- Screw in filling screw and oil mist filter and put on counter nut.



Oil exchange

(required after the first 100 operating hours, after general overhaul and every 6 months)

- Allow pump to run for approx. 30 minutes (operating temperature) and switch off.
- Put collector bowl (1.5l) under oil drain screw (11).
- Unscrew vacuum tube (1).
- Unscrew oil drain screw (11), let oil drain off completely.
- Switch on pump.
- Fill small amount of oil in suction nozzle (1) for rinsing.
- Switch off pump.



The pump must not run dry.

- Insert oil drain screw (11).
- Unscrew oil mist filter (7) and filling screw (4). Fill in 1.25 l oil (Edwards No. 15).
- Insert filling screw.
- Screw in oil mist filter and put on counter nut.
- Screw on vacuum tube (1).
- Let pump run with gas ballast for 3 to 12 hours (cleaning of fresh oil).
- Turned gas ballast valve (2) fully anticlockwise.

Control of oil mist filter (7)

- Drain precipitated oil regularly (acc. to experience).
- Open drain screw (8) and collect oil in clean vessel (100ml). If the oil is clean use it as refill for the rotary pump.



Never use contaminated oil as refill.

Exchange filter insert if the oil mist output increases

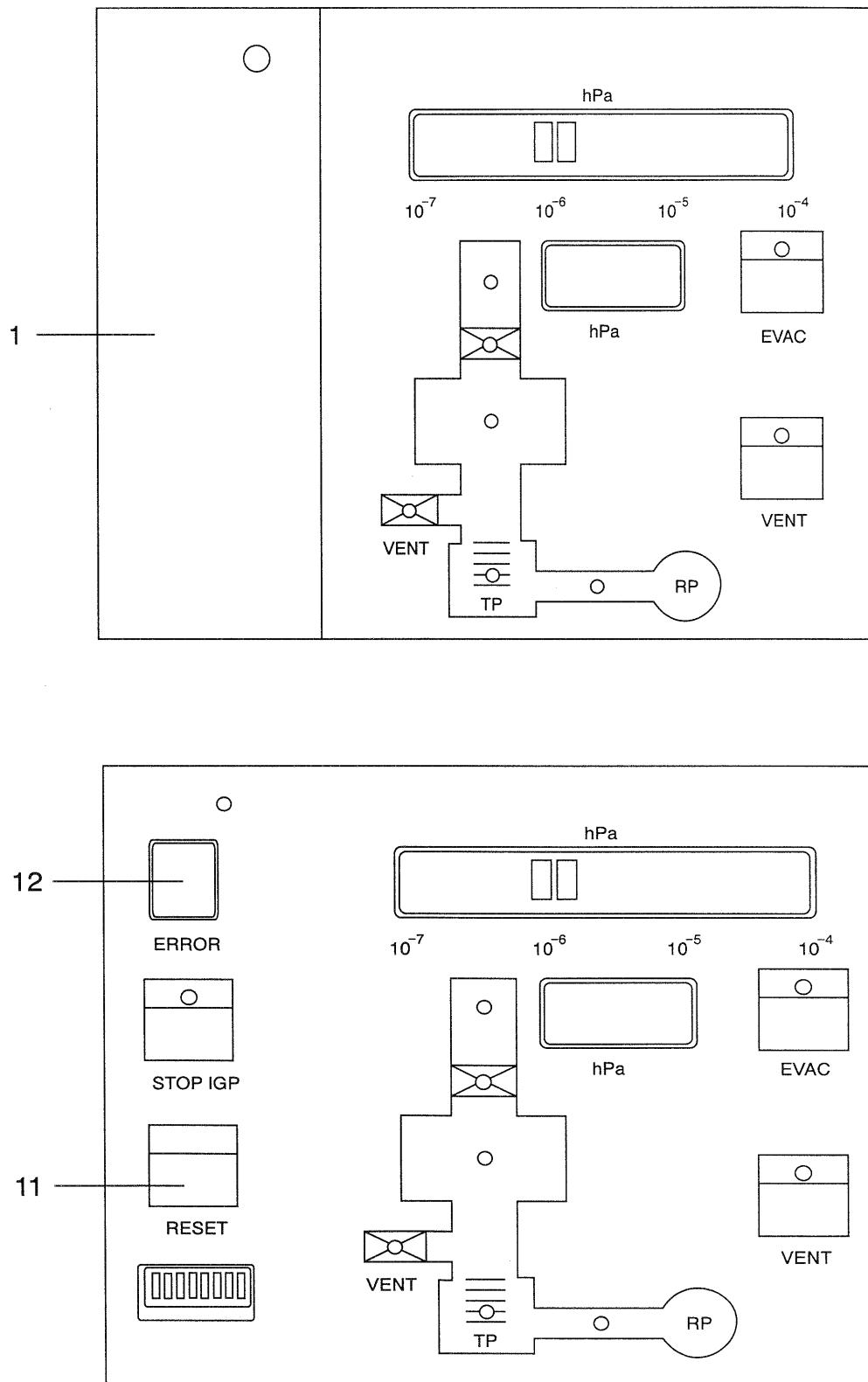
- Drain oil.
- Unscrew nut (5). Take off lid (6),
- Disassemble retaining nut and sealing ring of filter insert
- Pull off filter
- Assemble new filter in reverse order.

5.8.2 Control of vacuum tubes

If you suspect leaking, check the connection of both prevacuum tubes.

- From rotary pump (2) to insulating block (3),
- From insulating block to instrument output.

5.9 Error messages of vacuum system



The vacuum system is equipped with an automatic monitoring system, which gives an error message and resets the vacuum system to a safe operating state.

- When cover (1) is opened, the error message is displayed on **ERROR (12)**.
- Restart with key **RESET** (11) after elimination of the error.

The following codes are output:

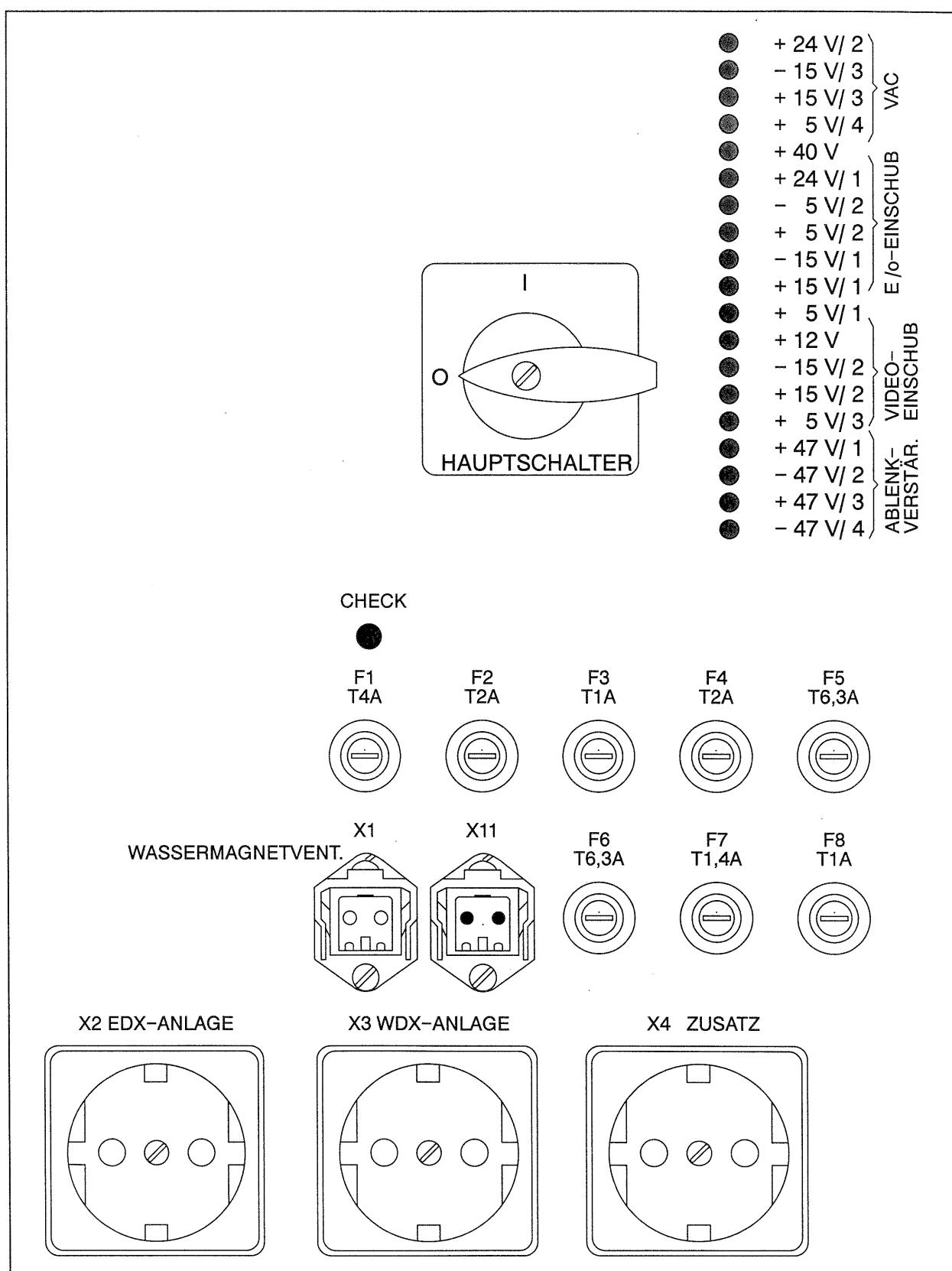
- Error 0:** no error
- Error 1:** the high vacuum trip point was achieved during pump-down,
the vacuum deteriorates during operation (vacuum breakdown).
- Error 2:** pre-vacuum switching point is not achieved within 80 s.
- Error 3:** the turbomolecular pump does not achieve 80% of standard speed within 4 min.
- Error 4: *)** the turbomolecular pump becomes too hot.
- Error 5: *)** turbomolecular pump controller becomes too hot.
- Error 6: *)** turbomolecular pump switches off during normal operation:
220 V not available or supply line interrupted.
- Error 7:** high-vacuum trip point not achieved within 25 min.
- Error 8: *)** speed of turbomolecular pump falls below 80% of standard speed in normal operation.
- Error 9:** pre-vacuum switching point is achieved during pumpdown, the vacuum deteriorates
during normal operation (pre-vacuum breakdown).
- Error E: *)** voltage on high-vacuum measuring tube less than 0,1 V:
measuring tube defective or measuring line broken.



Please call the Technical Service if any of the errors marked with an asterisk (**4, 5, 8** and **E**) occurs.

5.10 Electrical power supply

Main switch and fuses, and outlets for special attachments are on the back panel of the electronic console.



5.10.1 Main switch

 The main switch switches off the entire electronic system including the vacuum system.
NB: the line outlets X2, X3 and X4 are not switched off by the main switch.

5.10.2 Voltage displays on power supply

The most important supply voltages in the instrument are monitored; if they are active a green LED on the power supply is on. There are 4 major power supply groups:

Vacuum system	+24 V
	-15 V
	+15 V
	+ 5V
Electron optics	+40 V
	+24 V
	- 5 V
	+ 5 V
	-15 V
	+15 V
Video processing	+12 V
	-15 V
	+15 V
	+ 5 V
Deflection	+47 V
	-47 V
	+47 V
	-47 V

If any of the voltages fails, all others are automatically switched off, also in case of temperature rise due to water shortage in the instrument.

5.10.3 Fuses for power supplies and sockets

To find out which voltage failed, push the key **CHECK**; it activates the voltages for several seconds. The LEDs then display which voltage failed. If a whole group failed, check the corresponding fuse:

F1	EDX system	4.0 A SB
F2	WDX system	2.0 A SB
F3	attachment	1.0 A SB
F4	video rack	2.0 A SB
F5	supply of electron optics	6.3 A SB
F6	deflection	6.3 A SB
F7	vacuum system	1.4 A SB
F8	magnetic valve for water supply	1.0 A SB

Exchange fuse.

If the fuse blows after short time, call Technical Service.

Two fuses are provided on the back panel of the column unit for the high-voltage system. Pull the line plug:

F1	high voltage	2.5A SB
F2	high voltage	2.5A SB

 Exchange fuses only if the instrument is switched off.

5.11 Pin assignment of plugs and sockets

5.11.1 Line outlets not switched

The following line outlets for the connection of line-driven attachments are on the back panel of the instrument:

X2	for EDX system:	220V / 50-60Hz	4A SB
X3	for WDX system:	220V / 50-60Hz	2A SB
X4	for attachment:	220V / 50-60Hz	1A SB

5.11.2 Line outlets switched

The line outlet for the rotary pump on the back panel of the column unit is automatically switched by the vacuum system.

5.11.3 Magnetic valve for water supply

X1 is the special outlet for the magnetic valve for water supply.

Connection: 220V / 50-60Hz 1A SB.

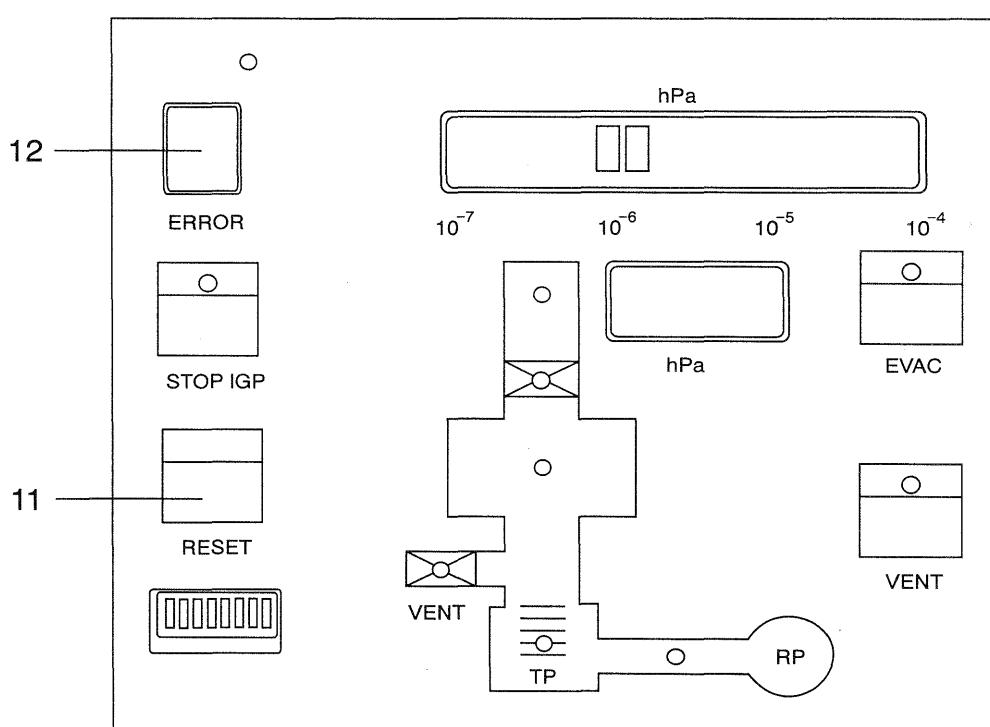
5.12 Troubleshooting

The DSM 960 A is a rugged instrument. Should an error occur, please look through the following list before you call the Technical Service.

5.12.1 Instrument stop

If the DSM 960 A is turned off completely, please check the following points:

- Line voltage
- Cooling water supply (active, water cold) (**WATER FAILURE**)
- Check power supply (5.10.3).



5.12.2 Trouble with the vacuum system

There will be an error message (5.9).

- Check the last seals in use (electron gun and especially seal of chamber door).
- RESET may be necessary after high-voltage arc-overs.

5.12.3 Trouble with the high voltage

High-voltage arc-overs

- If arc-overs occur frequently, switch off heating,
- Raise high voltage stepwise starting from 5kV, thereby observing the emission current display, which must return to zero after a few seconds. If this is not the case, there will be a gas discharge in the electron gun. Open the electron gun and clean electrodes (Wehnelt, anode).

Emission current too high

An emission current above 5 μA at 30kV with potentiometer **EMISSION CURRENT** at minimum indicates that the filament is too far in front in the Wehnelt cylinder. The shim (if any) is probably mounted not in front of but behind the filament.

- Remount the filament and adjust correct distance with the shim.
- Another cause may be contact between filament and Wehnelt cylinder. Recenter the filament.

Heating fails

- Displayed by red LED labelled **FAIL**. Filament needs replacement.
- Call the Technical Service if the filament is not burnt through, but the signal lamp is on.

5.12.4 System

Operation of the instrument is not possible or only in part.

This may be the case after high-voltage arc-overs, because the system control is set into an undefined state.

- Press **RESET** to unlock it.
- If this does not bring about the desired result, switch off the instrument and on again.

6. Accessories

Electron Gun

Directly heated LaB6 filament, automatic slow warm up circuit (requires differential vacuum system 348720-9009)	348749
Electrostatic beamblanking system:	345854
Special gun heating device (required for LaB6 with beam blanking system configuration)	348720-0312
Special anode housing for beam blander	348720-8031

Detectors

BSE-detector, YAP-scintillator type for material contrast down to delta Z <1, fully TV compatible with automatic contrast and brightness control or manual adjustment, individual brightness meters	348708
BSE-detector, semiconductor diode type, retractable, specially for low voltage operation with low noise amplifiers, manual brightness and contrast controls, individual contrast- and brightness meters	348711
BSE-detector, 4 quadrant semiconductor diode type, retractable, manual brightness and contrast controls. Quadrants individually selectable	348728
Robinson BSE-detector, retractable	345844
Robinson BSE-detector motorized retraction	345845
CL-detector, retractable, fully TV compatible, wavelength range 300 - 800 nm, with automatic brightness and contrast control or manual adjustment, individual contrast and brightness meters	348712
Digital specimen current measuring system, autoranging from 10-13A to 10-6A with 4-digit display	348762
CCD-TV-camera with chamber illumination and display on monitor Parallel mounting to tilt axis. Automatic interlock with detectors	348756 - 9901

Accessories for Standard Stage

Extra stub holder W.D. 30	348321-0226
Extra stub holder W.D. 25	348321-8028
Extra stub holder W.D. 10	348321-8029
Mechanical adapter for macrostage holders	348321-8030
Specimen stub with integrated Faraday cup	348342-8055
45° specimen stub holder for 1 stub	348342-8045

Accessories for Macro Stage

45° specimen stub holder for 1 stub	348342-8045
45° specimen stub holder for 4 stubs	348342-8044
90° specimen stub holder for 2 stubs	348342-8043
Extra specimen stub holder plate for 5 stubs	348342-8042
Extra spacer 15 mm	348342-8046
Extra spacer 30 mm	348342-8047
Extra spacer 50 mm	348342-8048
Wafer holder 100 mm (4 inch)	348342-8071
Wafer holder 125 mm (5 inch)	348342-8069
Wafer holder 150 mm (6 inch)	348342-8070
Holder for four polished metal specimens with integrated Faraday cup	348342-9005
Holder for 1 polished metal specimen (40 mm dia. max) with integrated Faraday cup	348342-8049
Holder for 1 polished metal specimen (1 inch dia. max) with integrated Faraday cup	348342-8050
Specimen clamp holder	348342-9006
Specimen stub with integrated Faraday cup	348342-8055
Magnetic damper	348342-9007

Feedthroughs for chamber doors(Door with ports required)

Feedthrough 2 x 9 poles D-sub	348742-8037
Feedthrough 2 x 15 poles D-sub	348742-8038
Feedthrough 2 x 25 poles D-sub	348742-8039
Feedthrough 9 x Coax SMA-type	348742-8036

Vibration Isolation System

Autolevelling system	348703-9015
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Electronic Accessories and Software Packages

Selected Area Channeling Pattern (SACP) module Rocking angle 2 to 16 highly linear	348767
Signal mixer for continuous mixing of 2 out of 4 different detector signals, additive or subtractive with brightness offset	348766
Measurement system for distance on x Horizontal distance between vertical bars with display of distance in top line of monitor. Calibration of the measurement system through menu	348755
Autofocus system Autofocus coarse, operating range 50 mm WD Autofocus fine, operating range 2 mm WD	348331-9028
Slow Scan interface with TTL-level actuation for external scan control with replay on photo unit	348368
System Control Interface for complete external control of the DSM960A via 2 RS232 interface lines. Includes Slow Scan Interface	348361
Digital Image Transfer Interface Imagetransfer to an external computer	348870
Dual Image for on-screen image comparison	348357

Monitors, Cameras and Hardcopies

2nd Monitor with driver card and cable set	348835
Rollfilm camera 120/220	348336-9004
Contax 35 mm camera	348336-9005
Video printer P 66e	345825
Color video printer CP 100 E	345836

Installation Parts

Magnetic water valve	348317-9001
Nitrogen pressure reduction valve (1" inner thread)	345659
Water chiller air cooled	345981
Water chiller water cooled	345980
Water pressure reduction valve and filter unit	340900-8904
Heatable adsorption trap for rotary pump	345919-9901
Compressor	345596

Miscellaneous

Table wedge	348726
Swing rack for control panels (required for installation of more than 2 accessories)	348737-9005
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Wavelength dispersive x-ray systems	
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