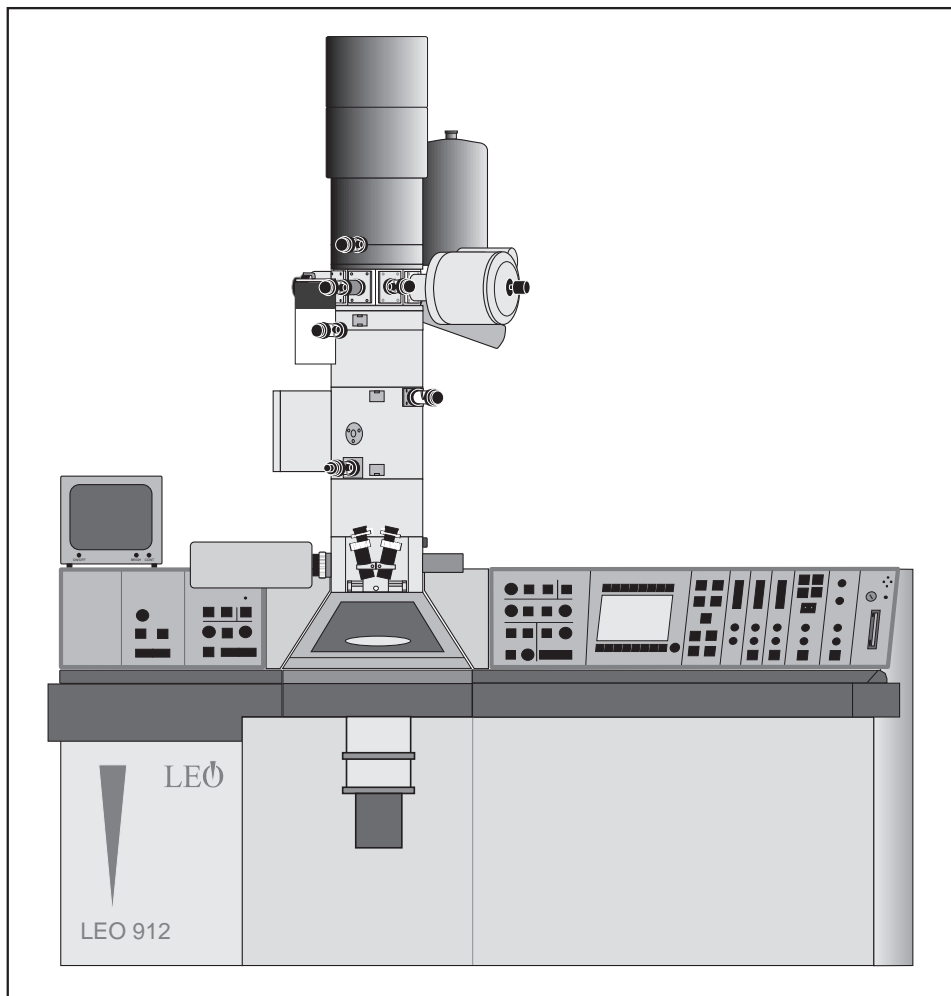


Transmission Electron Microscope

LEO 912 OMEGA



Operating Manual
G 34-656 e

LEO

Table of contents		
1	Description	
1.1	General	1-3
1.2	Functional description	1-5
1.2.1	Computer system	1-5
1.2.2	Electron optics	1-8
1.2.3	Vacuum system	1-42
1.2.4	Anticontaminator	1-48
1.2.5	Goniometer	1-49
1.2.6	Viewing binoculars	1-51
1.2.7	Fluorescent screens	1-52
1.2.8	Sheet-film camera	1-53
1.2.9	High-voltage unit	1-56
1.2.10	Memory/data management	1-57
1.2.11	Extensions	1-64
1.2.12	Operating controls - Control panels	1-65
1.3	Operating controls - Control panels	1-65
1.3.1	Operating controls - General	1-66
1.3.2	Operating controls - Goniometer positioning	1-67
1.3.3	Left control panel	1-68
1.3.4	Right control panel	1-71
1.3.5	Operating controls - monitor	1-74
1.4	Operating controls - Electron-optical column	1-77
1.4.1	Design of electron-optical column	1-77
1.4.2	Aperture drives	1-80
1.4.3	Slit aperture drive	1-81
1.5	Power supply cabinet	1-82

2	Important Information	
2.1	General information	2-3
2.1.1	Software licence agreement	2-3
2.1.2	Misuse of MS-DOS-run programs	2-3
2.1.3	Service contract	2-3
2.2	Safety precautions	2-4
2.2.1	Safety precautions for the use of beryllium (Be)	2-4
2.2.2	Safety precautions for the use of liquid nitrogen	2-6
2.2.3	X-ray safety	2-8
2.2.4	Electrical safety	2-9
2.3	Important precepts	2-10
2.4	Important prohibitions	2-11
2.5	Maintenance	2-12

3	Menu guidance	
3.1	Introduction	3-3
3.1.1	Menu guidance	3-3
3.1.2	The menu system	3-5
3.1.3	Keyboard functions	3-6
3.2	Menu START	3-9
3.3	Main menu	3-11
3.4	Menu PARAMETERS	3-15
3.5	Menu GUN	3-59
3.6	Menu GONIOMETER	3-68
3.7	Menu CAMERA	3-79
3.8	Menu VACUUM	3-97
3.9	Menu δE	3-103
3.10	Menu IMAGE (option)	3-111
4	Microscope Operation	
4.1	EM system turn- ON	4-3
4.2	High-voltage selection	4-6
4.3	Basic settings after turn-ON	4-7
4.3.1	Insertion of condenser aperture	4-7
4.3.2	Spectrometer adjustment	4-7
4.3.3	Adjustment of illumination system	4-9
4.3.4	Compensation of SPOT astigmatism	4-11
4.3.5	Beam Alignment	4-12
4.3.6	Adjustment of the eucentric plane	4-13
4.3.7	Adjustment of beam incidence	4-14
4.3.8	Centration of objective lens aperture	4-15
4.3.9	Compensation of imaging astigmatism	4-15
4.4	Microscope settings	4-18
4.4.1	Emission current	4-18
4.4.2	Filament current	4-18
4.4.3	Image brightness	4-19

4.4.4	AIS	4-21
4.4.5	Magnification selection	4-22
4.4.6	Diffraction length selection	4-23
4.5	Microscopy	4-24
4.5.1	Specimen exchange	4-24
4.5.2	Specimen lock-in/out	4-26
4.5.3	Change between specimens	4-28
4.5.4	Use of the goniometer	4-30
4.5.5	Settings before screening	4-31
4.5.6	Low magnifications (LOW MAG = LM)	4-32
4.5.7	Systematic screening	4-35
4.5.8	Storage and location of specimen positions	4-36
4.5.9	Further goniometer settings from the menu	4-37
4.5.10	Eucentric tilt	4-38
4.5.11	Adjustment of Gaussian focus	4-39
4.5.12	Focus and defocus parameters	4-42
4.6	Viewing binocular adjustment	4-45
4.7	ESI imaging modes	4-46
4.7.1	Elastic imaging	4-46
4.7.2	Contrast tuning of thick specimens	4-47
4.7.3	Electron-spectroscopic imaging of thin specimens	4-48
4.7.4	Element-spectroscopic imaging	4-49
4.8	Brightfield / darkfield imaging	4-50
4.8.1	Brightfield imaging	4-50
4.8.2	Darkfield imaging	4-52
4.9	Diffraction	4-54
4.9.1	Selected-area diffraction with AIS apertures in M mode	4-55
4.9.2	Microbeam diffraction (Nanoprobe)	4-57
4.9.3	Convergent Beam Electron Diffraction (CBED)	4-58
4.9.4	Low-angle diffraction	4-60
4.10	Photography	4-61
4.10.1	Single exposures	4-61
4.10.2	Camera adjustment	4-62
4.10.3	Operation of sheet-film camera	4-65
4.10.3.1	Ventilation and pumpdown of camera chamber	4-65
4.10.3.2	Loading and removing films (general)	4-65
4.10.3.3	Adapting the sheet-film camera to the cassette type.	4-66
4.10.3.4	Loading cassettes and sheet-film camera	4-66

4.10.3.5	Removal of exposed sheet film (unloading the camera)	4-68
4.10.3.6	Sheet-film transport outside the camera	4-68
4.10.3.7	Desiccator	4-68
4.11	Backup messages	4-69
4.12	Storage of user data	4-70
4.12.1	Storage on hard disk	4-70
4.12.2	Storage on floppy	4-71
4.13	Loading user data	4-71
4.13.1	Loading user data from a floppy disk	4-71
4.13.2	Loading user data from hard disk	4-72
4.14	EM system turn-OFF	4-73
4.15	Status messages	4-74
4.15.1	Status messages of vacuum system	4-74
4.15.2	Error messages on EL display	4-79
5	Adjustment	
5.1	AIS adjustment	5-3
5.1.1	Overview	5-3
5.1.2	Fine adjustment of entire system	5-6
5.1.3	Coarse adjustment of entire system	5-14
5.2	Alignment	5-20
5.2.1	Calibration to factory-set values	5-20
5.2.2	Alignment of TEM and SPOT illumination	5-21
5.2.3	Filament centration	5-23
5.2.4	Optimization of beam alignment (BEAM ALIGNMENT)	5-28
5.2.5	Adjustment of optimum imaging plane	5-30
5.2.6	Adjustment of beam incidence	5-31
5.2.7	Insertion and centration of objective lens aperture	5-32
5.2.8	Adjustment of imaging stigmator	5-32
5.2.9	Adjustment of illumination stigmator	5-33
5.2.10	Alignment in LM mode	5-36
5.3	Different settings and calibration	5-42
5.3.1	MDF setting	5-42
5.3.2	Dose rate calibration	5-43

6	Care and Maintenance	
6.1	General	6-3
6.2	Filament exchange	6-3
6.3	Anode exchange	6-6
6.4	Electrode cleaning	6-7
6.5	Assembly of filament holder	6-10
6.6	Mechanical adjustment of filament	6-11
6.7	Components of the tool kit	6-12
6.8	Reactivation after electrode exchange	6-13
6.9	Care of specimen holders	6-15
6.10	Aperture exchange	6-17
6.10.1	Aperture removal	6-17
6.10.2	Exchange of objective lens apertures and selector apertures	6-18
6.10.3	Condenser aperture exchange	6-19
6.11	Care of vacuum pump (rotary pump)	6-20
6.12	Cleaning the filter mats in the power supply cabinet	6-21
6.13	Preparation of backup floppies	6-22
7	Supplements	
8	Introduction to Imaging Electron Energy Loss Spectroscopy	
8.1	General	8-3
8.2	Elastic and inelastic scattering processes	8-4
8.3	Elastically scattered electrons	8-5
8.4	Inelastically scattered electrons	8-6
8.5	Multiply scattered electrons	8-7
8.6	The electron energy loss spectrum	8-8

8.6.1	Range around 0 eV energy loss (zero loss peak)	8-8
8.6.2	Range of approx. 10-30 eV (plasmon peak)	8-8
8.6.3	Range > 50 eV (inner shell losses)	8-9
8.6.4	Background	8-9
8.7	Electron Energy Loss Spectrometer	8-10
8.8	Electron-optical arrangement and operating principle of the OMEGA Imaging Electron Energy Loss Spectrometer	8-11
8.9	Imaging methods	8-14
8.10	Use of the LEO 912 OMEGA for electron-spectroscopic imaging	8-17
8.11	Recording of an EEL spectrum	8-18
8.12	Evaluation of element-spectroscopic images	8-20
8.12.1	Photographic subtraction	8-21
8.12.2	Computer-assisted image evaluation	8-21
9	Unassigned at the present time	
10	Installation Guide	
10.1	Before installation	10-3
10.2	Installation place requirements	10-4
11	Technical Data	
11.1	Gun	11-3
11.2	Illumination system	11-3
11.3	Objective lens	11-5
11.4	Specimen plane	11-6
11.5	Imaging system	11-7
11.6	Shutter housing and Viewing chamber	11-9

11.7	Instrument control and operation	11-10
11.8	Vacuum system	11-12
11.9	Camera system	11-13
12	Registers	
12.1	Abbreviations and Technical Terms	12-3
12.2	Index	12-6

Preface

This operating manual contains all the information necessary for the operation, adjustment and maintenance of the LEO 912 OMEGA Transmission Electron Microscope.

The operating manual describes the standard version of the device. Auxiliary equipment which you have optionally integrated in the LEO 912 OMEGA are described in separate documentary brochures. These additional publications are included in the second part of the operating manual.

Familiarize yourself with the contents of the operating manual before you begin working with the LEO 912 OMEGA. You will then be able to operate the LEO 912 OMEGA quickly and efficiently and respond properly to any problems or malfunctions that may occur.

Chapter 1 gives a detailed description of the LEO 912 OMEGA Transmission Electron Microscope. It presents the individual systems and explains their functions and how they operate. In this chapter you will find explanations of all the LEO 912 OMEGA controls.

Chapter 2 contains all the important instructions that should absolutely be obeyed when operating the LEO 912 OMEGA. Read carefully through the information in this chapter before working with the device. You will then be able to prevent personal injuries and damage to the equipment.

Adhering to the instructions given here is of utmost importance for operating the LEO 912 OMEGA, for improper operation may cause damage to health (X-rays, liquid nitrogen and beryllium).

Inobservance of the instructions may also result in the loss of warranty claims.

Chapter 3 gives a detailed description of the user interface of the LEO 912 OMEGA. Here you will find explanations of all the masks and the meaning of all the function keys of the individual menus as well as background information on the individual functions.

If you familiarize yourself with the arrangement of the menu structure and the general operating procedures before beginning work, you will be able to perform the work procedures described in chapter 4 "Microscope Operation" and chapter 5 "Adjustment" quickly, safely and successfully.

Chapter 4 describes all the operating procedures that can be performed on the LEO 912 OMEGA standard device. It gives all work steps in detail, starting with activation of the device, and then selection of parameters (basic settings), the various microscope settings and actual microscopy, etc.

One section provides information on the LEO 912 OMEGA status messages.

Chapter 5 "Adjustment" gives a detailed description of the adjustments to be performed on the LEO 912 OMEGA.

Chapter 6 contains all the information necessary for the maintenance and care of the LEO 912 OMEGA. The work procedures for exchanging parts, such as cathode and anode, filament, etc., are described in detail. If you perform the work given in chapter 6 carefully and with the required precision, this will contribute considerably to maintaining the operating efficiency of the LEO 912 OMEGA. With a well serviced device you will always achieve good microscopy results.

Chapters 7 is for appending supplements to this operating manual.

Chapter 8 describes the function of the spectrometer of the LEO 912 OMEGA. You will find an introduction to imaging electron loss spectroscopy.

Chapter 9 is unassigned at the present time.

Chapter 10 gives instructions on the installation of the LEO 912 OMEGA and the requirements at the installation site.

Chapter 11 contains the Technical Data of the LEO 912 OMEGA.

Chapter 12 contains an index and a list of the abbreviations used in this operating manual.

Important Notes

Technical details contained in the text and illustrations of this operating manual are subject to change.

The software described herein corresponds to the time of printing (Version 3.20).

Reprinting, translation or reproduction of any or all of this operating manual is prohibited without written consent.

© 1998	LEO Elektronenmikroskopie GmbH 73446 Oberkochen
--------	--



Description

Table of contents

1	Description	
1.1	General	1-3
1.2	Functional description	1-5
1.2.1	Computer system	1-5
1.2.2	Electron optics	1-8
1.2.3	Vacuum system	1-42
1.2.4	Anticontaminator	1-48
1.2.5	Goniometer	1-49
1.2.6	Viewing binoculars	1-51
1.2.7	Fluorescent screens	1-52
1.2.8	Sheet-film camera	1-53
1.2.9	High-voltage unit	1-56
1.2.10	Memory/data management	1-57
1.2.11	Extensions	1-64
1.3	Operating controls - Control panels	1-65
1.3.1	Operating controls - General	1-66
1.3.2	Operating controls - Goniometer positioning	1-67
1.3.3	Left control panel	1-68
1.3.4	Right control panel	1-71
1.3.5	Operating controls - monitor	1-74
1.4	Operating controls - Electron-optical column	1-77
1.4.1	Design of electron-optical column	1-77
1.4.2	Aperture drives	1-80
1.4.3	Slit aperture drive	1-81
1.5	Power supply cabinet	1-82

1.1

General

In the Transmission Electron Microscope (TEM) elastic and inelastic scattering processes are the most important interactions between primary electrons and the specimen. Inelastically scattered electrons in particular contain a great amount of information about specimen structure, mass distribution and thickness, and about the distribution of elements and molecules. Such information cannot be utilized in conventional TEMs, where inelastically scattered electrons even reduce image contrast and image sharpness.

But the integration of an imaging energy spectrometer in the imaging beam path of the TEM permits information contained in inelastically scattered electrons to be fully utilized, and considerably increases the quality of imaging and diffraction. The Energy Filter Transmission Electron Microscope (EFTEM) offers many more operating modes than conventional TEMs, e.g.:

- elastic brightfield imaging
- Electron Spectroscopic Imaging (ESI)
- Electron Spectroscopic Diffraction (ESD)
- Electron Energy Loss Spectroscopy (EELS)
- Element or structural contrast imaging
- Plasmon loss imaging
- Image EELS, etc.

Because of these advantages, filter electron microscopy has found worldwide acceptance within a very short time.

The LEO 912 OMEGA is the first EFTEM using a fully magnetic omega spectrometer. The easy, comfortable operation of the LEO 912 OMEGA is fully maintained by integration of the energy filter in the electron optical system of the instrument.

One of the major characteristics of the LEO 912 OMEGA are the completely new electron optics. The optically correct position of the essential elements of illumination and imaging systems and of the imaging spectrometer guarantees that objective lens and omega filter operate at fixed excitation in all illumination and imaging modes. This reduces adjustments by the user to a minimum.

The LEO 912 OMEGA features a Köhler illumination system for homogeneous, parallel specimen illumination. An automatic system assures that only the area imaged on the fluorescent screen is imaged at all magnifications, which optimally protects the specimen against damage by irradiation.

The modern “multiprocessor/multitasking” computer control of the instrument, efficient user guidance from a control monitor for interactive mode with the computer system, and some specific control elements permit easy and effective use even of extraordinary imaging and analysis modes.

The LEO 912 OMEGA is of modular design. All functions necessary for standard examinations are incorporated in the base instrument. It can be upgraded for all presently known imaging and analysis modes by corresponding hardware and software supplements.

All important instrument functions are remote-controllable by an external computer, and allow automation of any kind of functional operation.

Fig. 1-1 is an overall view of the LEO 912 OMEGA.

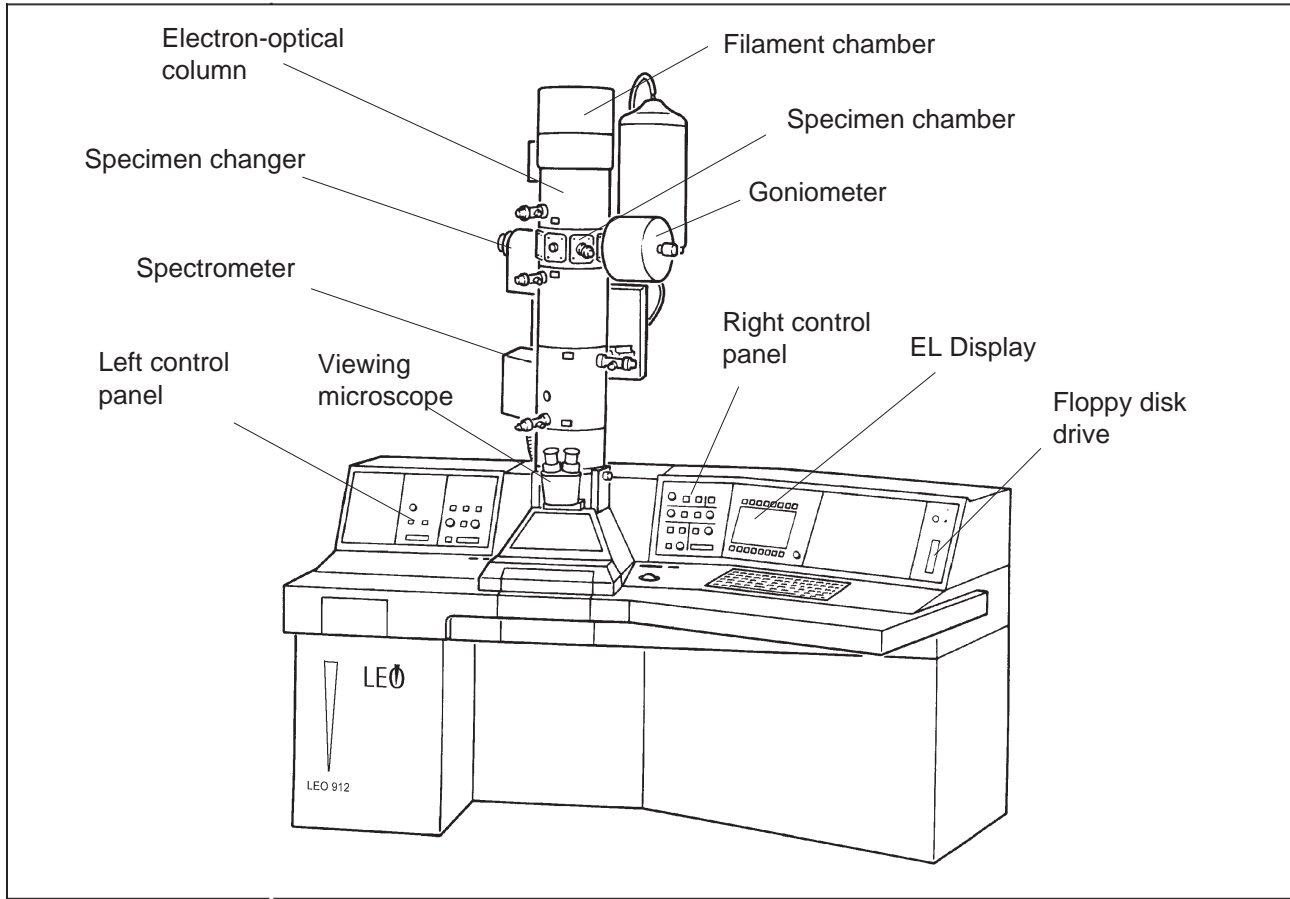


Fig. 1-1: Overall view of LEO 912 OMEGA

1.2 Functional description

1.2.1 Computer system

Overview

The LEO 912 OMEGA computer system comprises

- an AT-compatible host computer
- four microprocessor-controlled subcomputers
- a flexible data and program memory

Inputs for the computer system are made

- from two control panels to the left and right of the column
- by 16 function keys above and below the control monitor
- from a keyboard

Output units are

- a control monitor
- a printer

The computer architecture of the LEO 912 OMEGA allows instant operation without delay between start of operation and execution of a function. It also permits several functions such as magnification change and specimen shift to be executed simultaneously. The multiprocessor architecture relieves the central system control of monitoring and control functions.

Fig. 1-2 is the block diagram of the computer system which displays the interaction of the components.

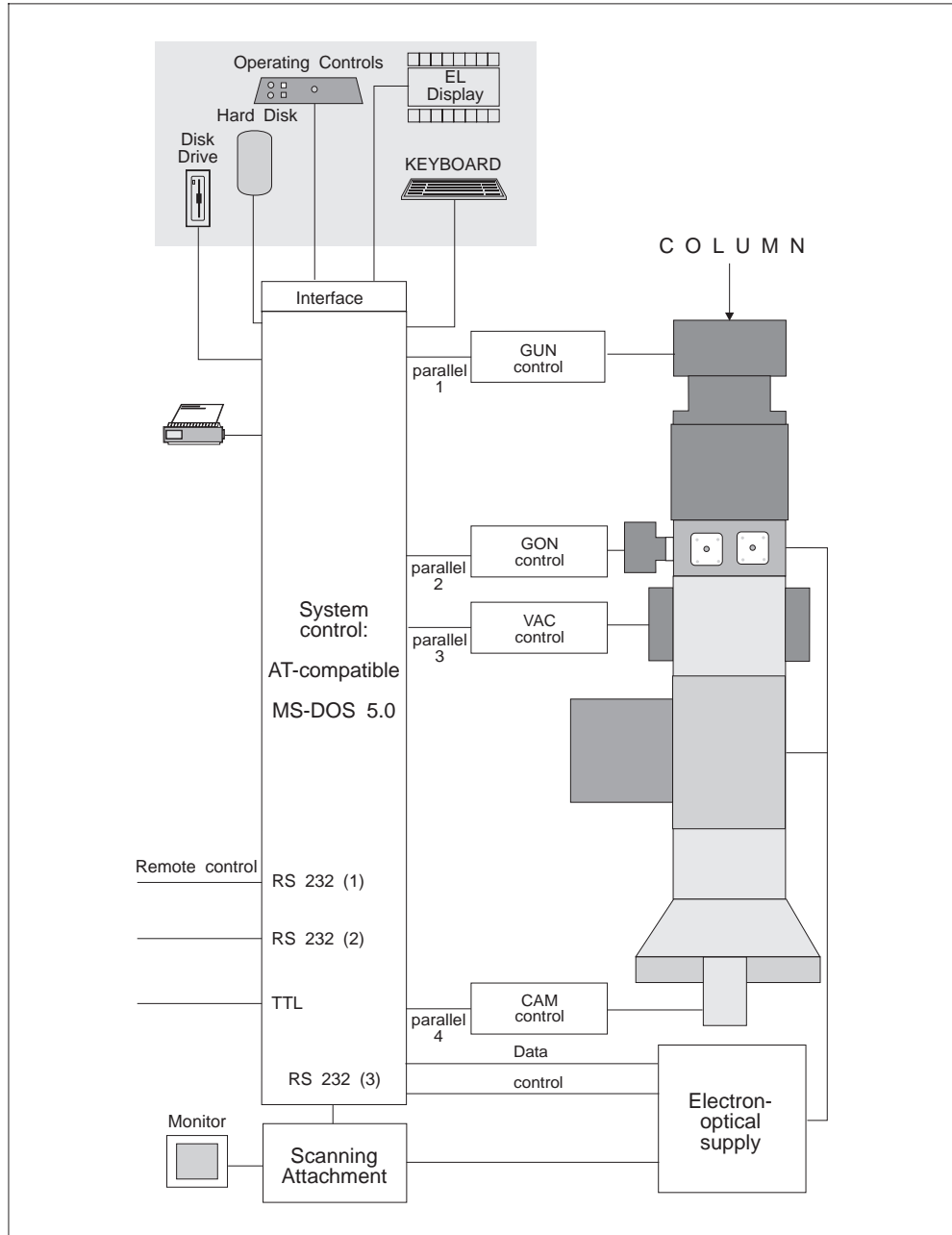


Fig. 1-2: Block diagram of computer system

Host computer

Base data of host computer and peripherals:

- AT-compatible processor
- MS-DOS operating system
- Three RS 232 serial interfaces, one for communication with the DSA Scanning Attachment, the other two for remote-control functions.
- 4 interrupt-controlled parallel interfaces for communication with the 4 subcomputers
- Winchester hard disk drive
- Disk drive for 3.5" disks with 1.44 MB data density
- Printer interface
- TTL interface

The host computer controls and monitors the entire electron-optical system including lenses, deflecting systems and stigmators.

Subcomputers

The subcomputers are independent units with separate processors. In the LEO 912 OMEGA they serve as

- Gun subsystem to control and monitor the high-voltage unit
- Goniometer subsystem to control and operate the five-axis, motorized, eucentric goniometer
- Camera subsystem to control the sheet-film camera and the components required for exposure such as fluorescent screen and shutter
- Vacuum subsystem for functional control of the vacuum system and to monitor the compressed-air and water supplies

Operating controls

The most important base functions of the instrument like focus, illumination or magnification adjustment, are always readily available to the user by incremental encoders or keys. When changing between imaging or illumination mode the computer will change the corresponding operating functions so that the base functions are always adjusted with the same operating controls. The corresponding operating modes are displayed by LEDs on the control panels and the control monitor. Together with the softkeys the latter provides for interactive operator guidance by menus, for preselection of specific operating modes of the LEO 912 OMEGA and change of electron-optical parameters and settings without the need of additional operating controls.

1.2.2**Electron optics**

The electron-optical system of the LEO 912 OMEGA consists of a total of ten lenses, and an imaging omega spectrometer integrated in the system as a 1:1 imaging element. The total system comprises the following optical components:

a) Illumination system

A flexible condenser system for Köhler illumination in TEM mode (imaging, selected area diffraction) and for SPOT illumination (spot analysis, scan mode, convergent beam electron diffraction).

b) Objective lens

A Riecke/Ruska-type condenser/objective single field lens with constant excitation, which guarantees a fixed position of the first diffraction or intermediate image.

c) First projector lens system

A three-lens magnification system to form an image of the first intermediate or diffraction image in the fixed entrance image plane of the following energy spectrometer.

d) Energy spectrometer

An omega imaging energy spectrometer which supplies an achromatic 1:1 image of its entrance image plane, and at the same time forms a spectrally dispersed 1:1 image of its entrance pupil (energy loss spectrum) from which the analyzer slit selects the desired energy field.

e) Second projector lens system

A two-lens magnification system to image the filtered image or diffraction pattern or the electron energy loss spectrum on the fluorescent screen or the camera system of the microscope.

Figs. 1-5 through 1-8 display schematically the entire electron optics of the LEO 912 OMEGA including lenses, apertures, deflecting systems, stigmators and omega spectrometer. The host computer controls the electron-optical components described above.

Illumination program

It includes the settings for the individual operating modes like

- Imaging and diffraction (IMAGE / DIFFRACTION)
- Brightfield and darkfield imaging (BF / DF)
- **A**utomatic **I**llumination-aperture **S**election (AIS)
- **M**anual **I**llumination-aperture **S**election (MIS)
- **M**inimum **D**ose **F**ocusing (MDF)
- **L**ow **M**agnification (LM)
- Widefield illumination (TEM illumination)
- Spot illumination (SPOT illumination)

Imaging program

It is coupled with the illumination program and includes a.o.

- the magnification program
- the optimized correction of image aberrations

There are various lens programs:

- to compensate lens rotation
- to minimize image aberrations
- for user-definable parameters (option FREE LENS CONTROL)

The illumination and imaging programs are generally coupled by the host computer. The operating parameters are automatically optimized when changing the magnification and the illumination or imaging mode, which considerably facilitates the operation of the LEO 912 OMEGA.

The OMEGA filter (energy loss spectrometer)

Fig. 1-3 shows the principle of the omega filter: it consists of four sector field magnets and a combined hexapole/quadrapole corrector in the symmetry plane of the system. Because of the exactly symmetrical construction of the spectrometer, the position of the image planes in the filter, and the arrangement of the spectrometer between the two projector lens systems, a single corrector element suffices to compensate image aberrations. The design provides for high flexibility for all applications, and is characterized by low sensitivity to strayfields, minimum hysteresis effects and a minimum of adjustments.

The first projector lens system produces an entrance image in the first magnetic sector field, and the spectrometer forms an achromatic 1:1 image of this image in its exit image plane. All electrons from one object point are focused in one image point in the achromatic plane (spatial focusing). Electrons of equal energy but from different object points are focused in the energy-dispersive plane (energy focusing). Defined energy electrons can be filtered from the image by a slit aperture.

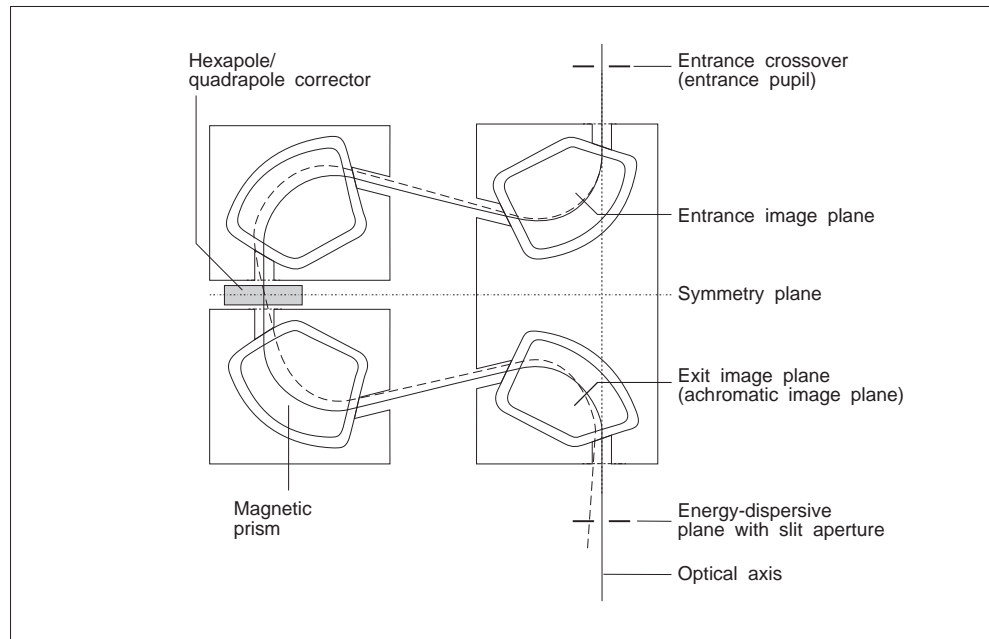


Fig. 1-3: OMEGA Spectrometer

Fig. 1-3 shows the compact design of the omega spectrometer. The entrance and exit image planes lie within the system. Spectrometer tuning by digital control of the primary electron energy in increments of 0.2eV; the excitation of the spectrometer magnets remains constant.

Fig. 1-4 shows in imaging mode the first projector lens system images the gun in the spectrometer's fixed entrance pupil (entrance crossover). The spectrometer produces a spectrally dispersed 1:1 image of the entrance pupil in the energy-dispersive plane, which represents an EEL spectrum of the selected object area. Any energy window for object imaging can be adjusted by the analyzer slit in the fixed energy-dispersive plane. The width of the analyzer slit defines the energy resolution of the image. The analyzer slit lies exactly on the optical axis of the microscope.

A specific electron energy for specimen imaging or serial recording of an energy spectrum is selected by the defined increase in primary electron energy which exactly corresponds to the selected energy loss in the specimen. Because of the axial orbits of the selected energy loss electrons, the excitation of imaging system and spectrometer remains constant, and the position of the analyzer slit is not changed. The energy field is selected manually or automatically by computer control in digital increments of 0.2eV.

Version 3.20

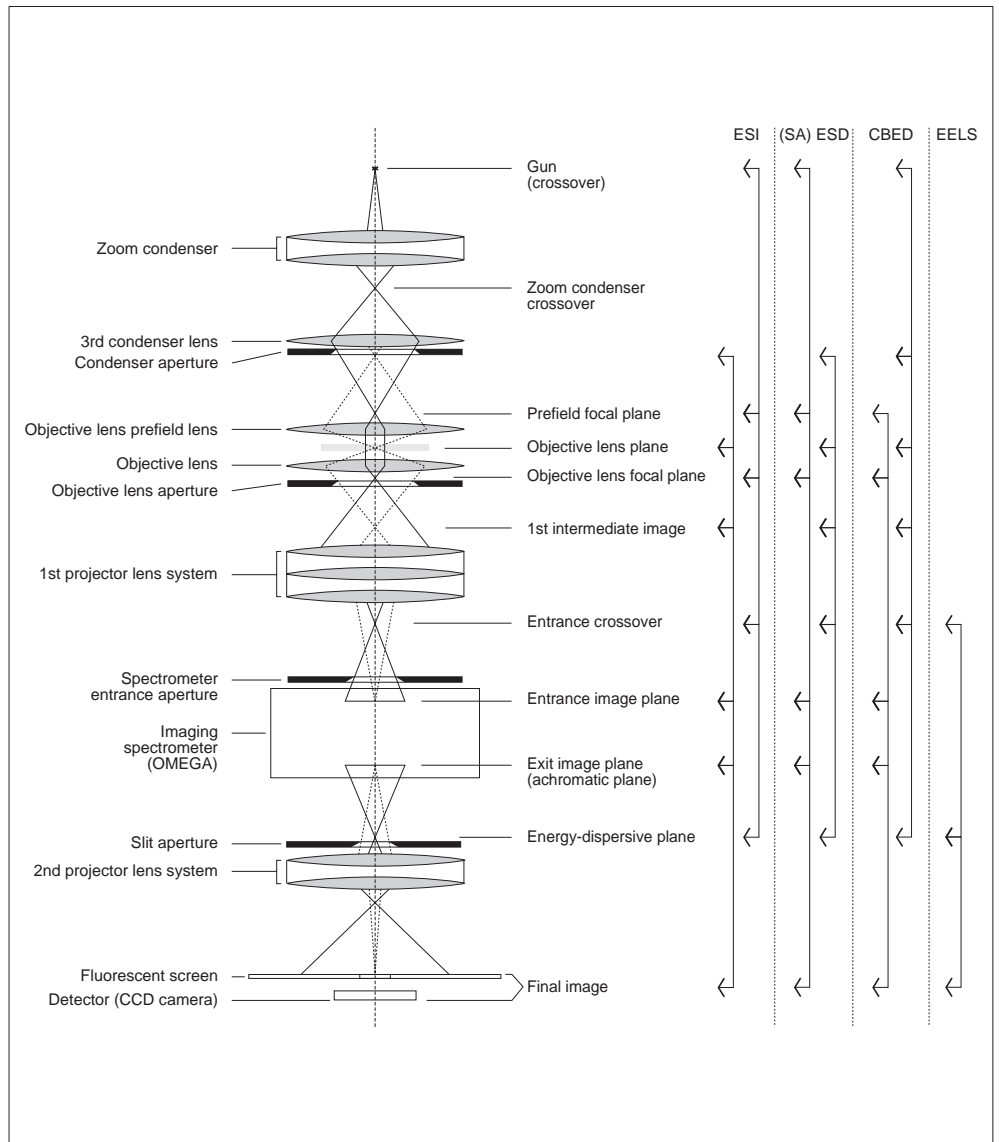


Fig. 1-4: OMEGA Spectrometer

Fig. 1-4 shows the electron-optical design of the LEO 912 OMEGA. Displayed are the illumination (solid lines) and imaging beam paths (dotted lines). The imaging spectrometer produces an achromatic 1:1 image of the intermediate image or diffraction pattern formed by the first projector lens system. It also produces a spectrally dispersed 1:1 image of its entrance pupil from which the analyzer slit selects the energy field wanted for further imaging. The optically conjugated planes of the system are displayed for electron spectroscopic imaging (ESI), electron spectroscopic diffraction (ESD, SAESD, CBED) and for EEL spectroscopy.

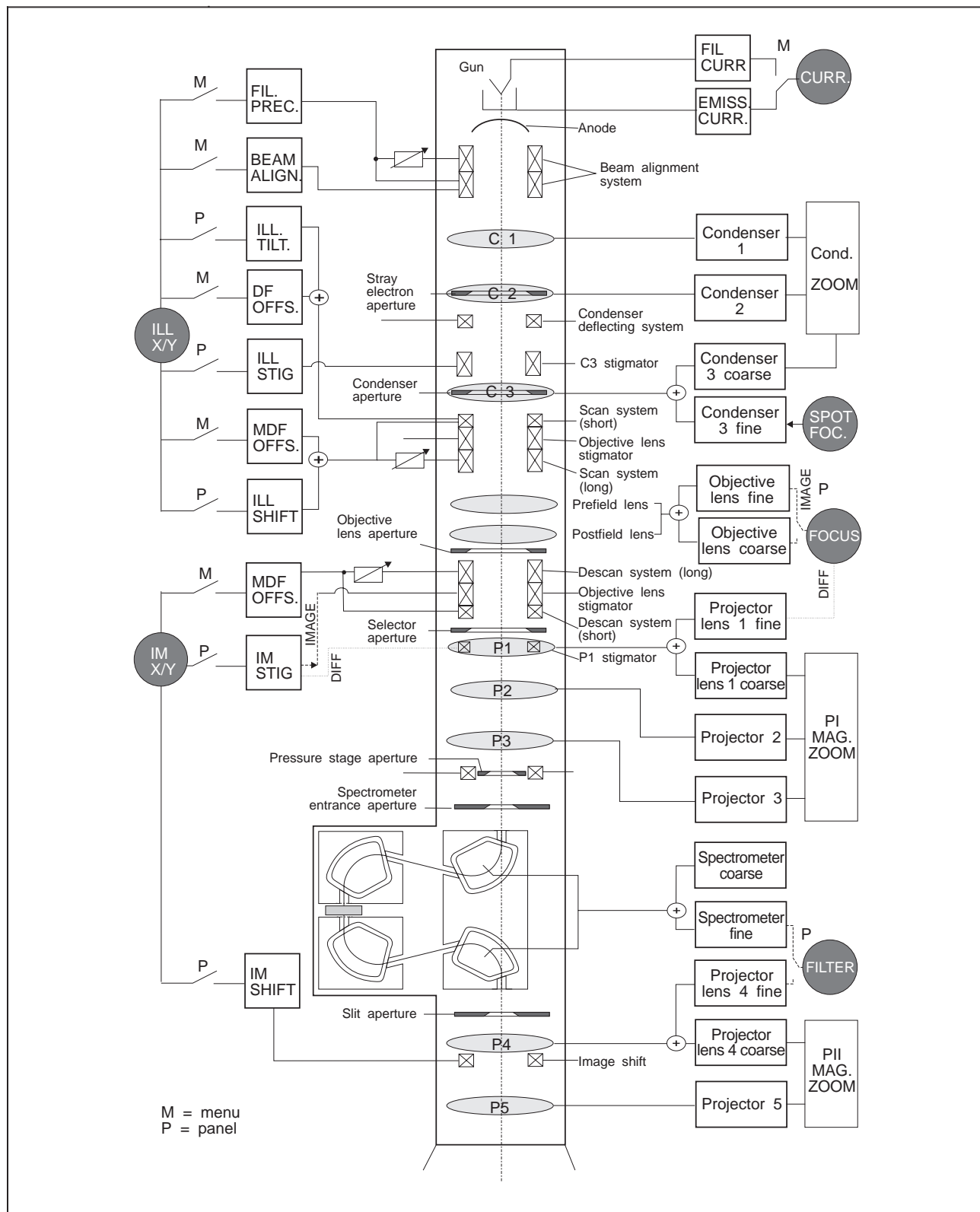
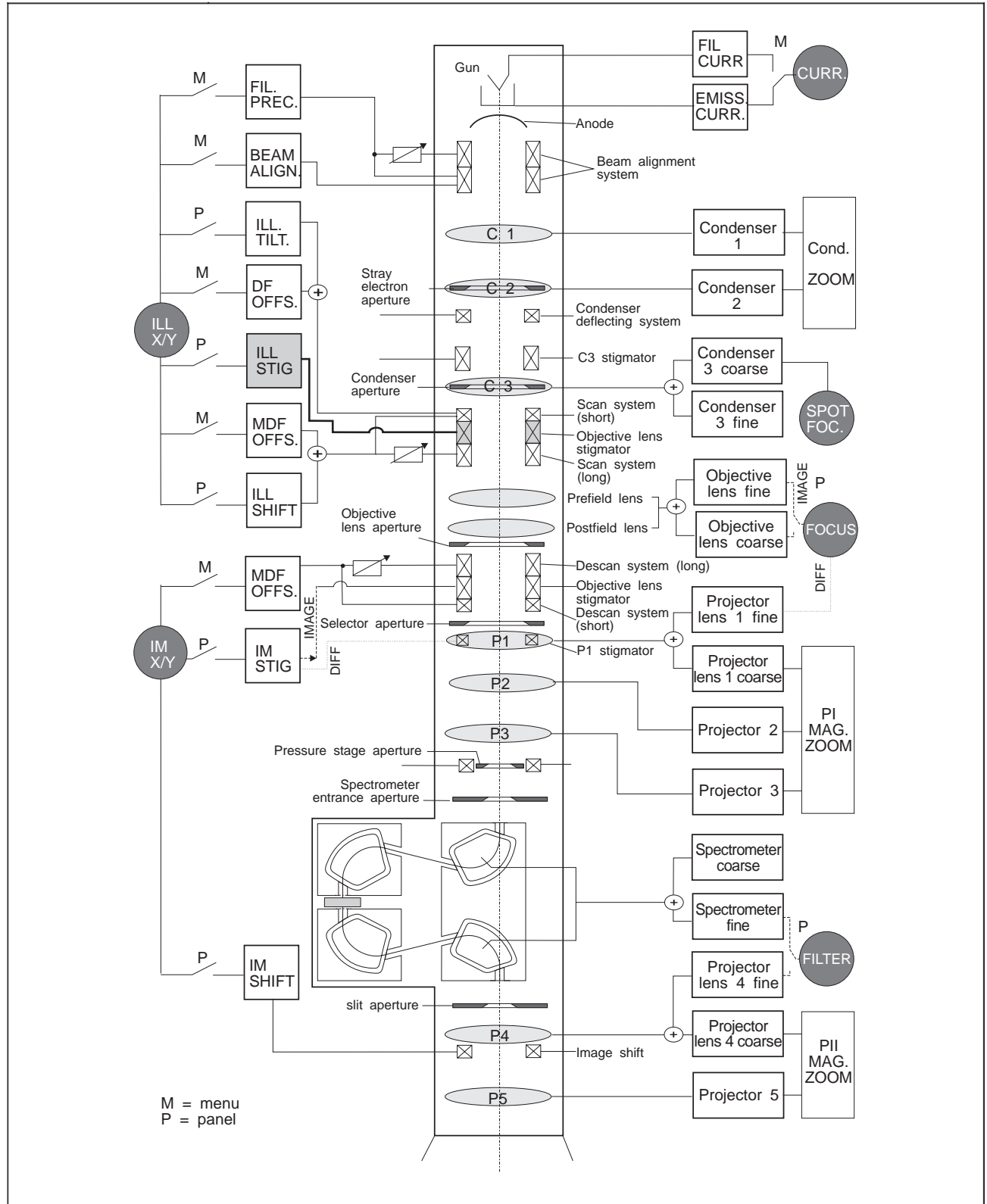


Fig. 1-5: Schematic view of electron optics (MAG mode TEM III)



Version 3.20

Fig. 1-6: Schematic view of electron optics (MAG mode SPOT III)

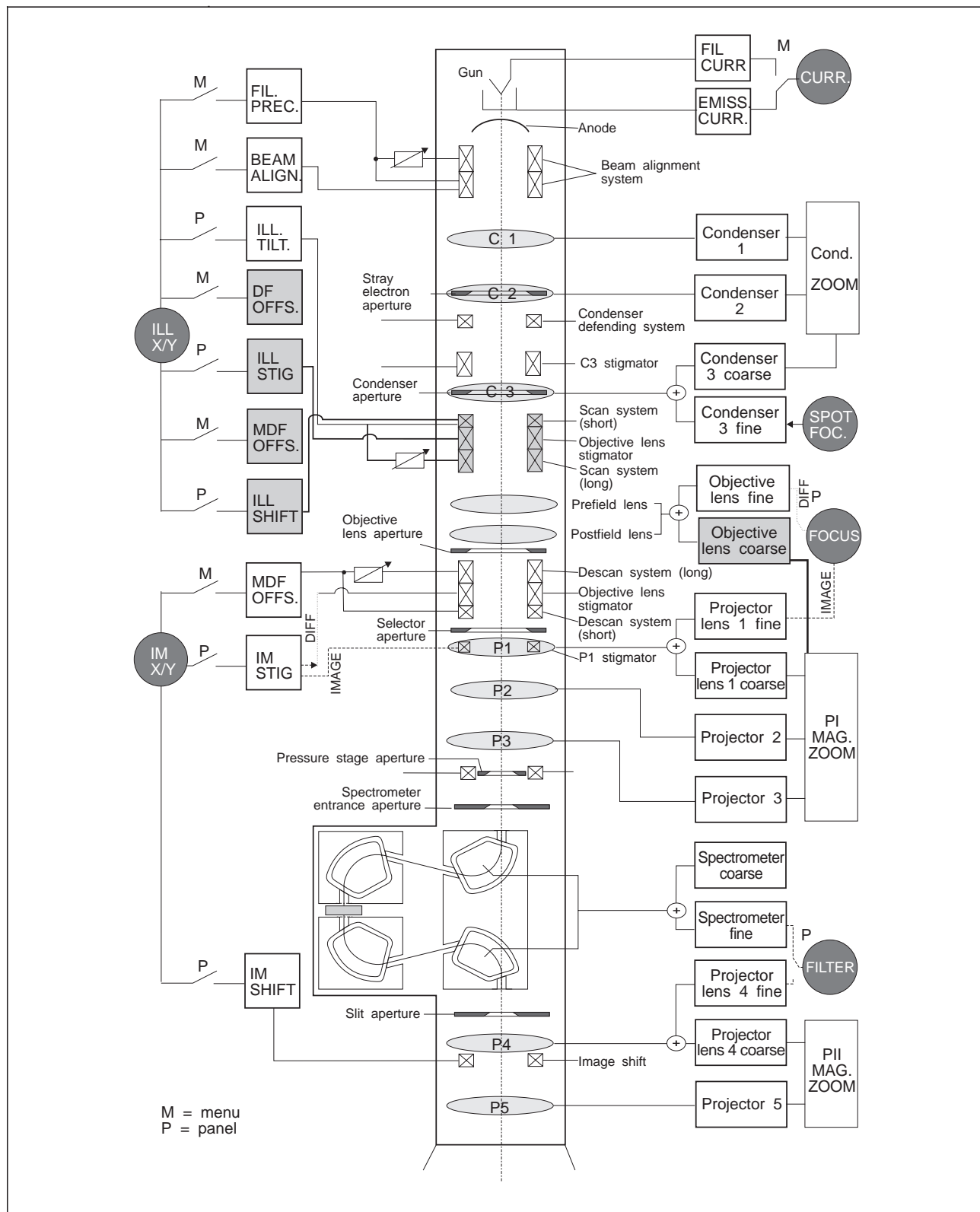
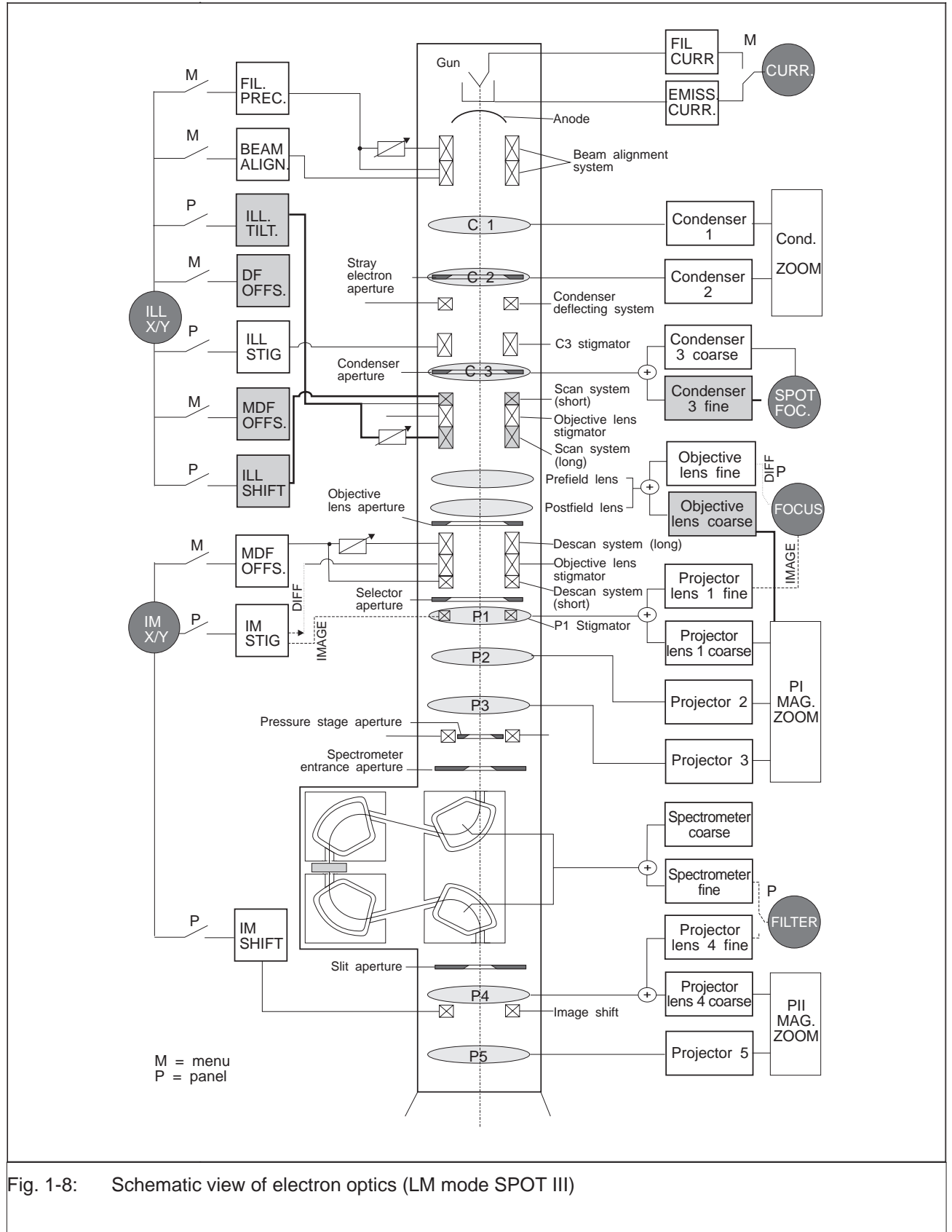


Fig. 1-7: Schematic view of electron optics (LM mode TEM III)



The illumination system

A single-field condenser objective lens is the most suitable for the analytical Transmission Electron Microscope (TEM). The symmetrical position of the specimen in the center of the pole piece gap permits

- high-resolution TEM mode
- the generation of small electron probes for analysis (SPOT mode)
- Selected Area Diffraction
- Scan mode
- optimized arrangement of the detectors for the scanning modes (SE, BSE, EDX)
- maximum specimen tilt

Previously, with this type of objective lens, either an auxiliary lens or a considerably changed excitation of the objective lens have been used for TEM illumination, whereas the LEO 912 OMEGA applies the Köhler illumination principle known from light optics.

In the analytical TEM, optimized illumination must meet the following requirements:

- The illumination angle must be variable to match coherence of illumination, image brightness and specimen contrast.
- The size of the illuminated specimen area should not be much larger than the imaged specimen area, to prevent irradiation damage and contrast-reducing scattering electrons.
- The beam should be vertically incident on all spots of the specimen to prevent off-axis image distortion.
- The specimen should be homogeneously illuminated.
- Easy change between TEM and SPOT illumination.
- Tilt and shift of illumination should be independently adjustable.

Illumination modes

There are two possibilities of specimen illumination in the LEO 912 OMEGA (Fig. 1-9):

TEM widefield illumination for

- TEM imaging and
- Selected Area Diffraction

SPOT illumination for

- Materials analysis (EDX)
- Diffraction examinations (Nanoprobe, **Convergent Beam Electron Diffraction (CBED)**)
- **Scanning Transmission Electron Microscopy (STEM)**)

TEM illumination

The illumination system consists of 3 condensers. The 1st and 2nd condensers form a zoom system which images the crossover of the gun variably reduced in the constant **Zoom Image Plane (ZIP)**.

In *Magnification (MAG (M)) mode* for magnifications from 1,000x the 3rd condenser transmits the crossover image to the front focal point of the objective prefield lens. The illuminating cones for each object point are thus parallel with the optical axis and have the same aperture (σ).

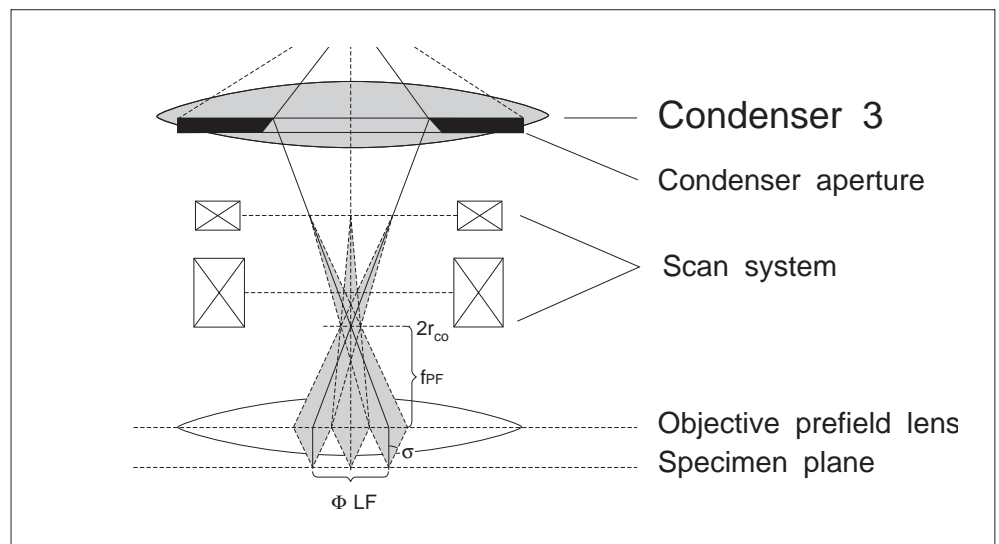


Fig. 1-9: Illuminating cones for several object spots

The illuminating aperture σ is given by the radius of the crossover image r_{co} , divided by the focal length of the objective prefield lens f_{PF} , and can be varied by different excitation of the condenser zoom lenses C1 and C2.

The condenser aperture is placed in the principal plane of the 3rd condenser lens and limits the luminous field. The size of the luminous field LF is defined by the diameter of the condenser aperture and its demagnification by the objective prefield lens.

Luminous field and illuminating apertures are selected by separate independent variables and are thus also variable independently of each other.

SPOT illumination

For SPOT illumination in MAG mode the 3rd condenser images the crossover in the entrance image plane of the objective prefield lens, which produces on the specimen an approx. 20x reduced crossover image. Here, the condenser aperture acts as condenser aperture for the focused spot.

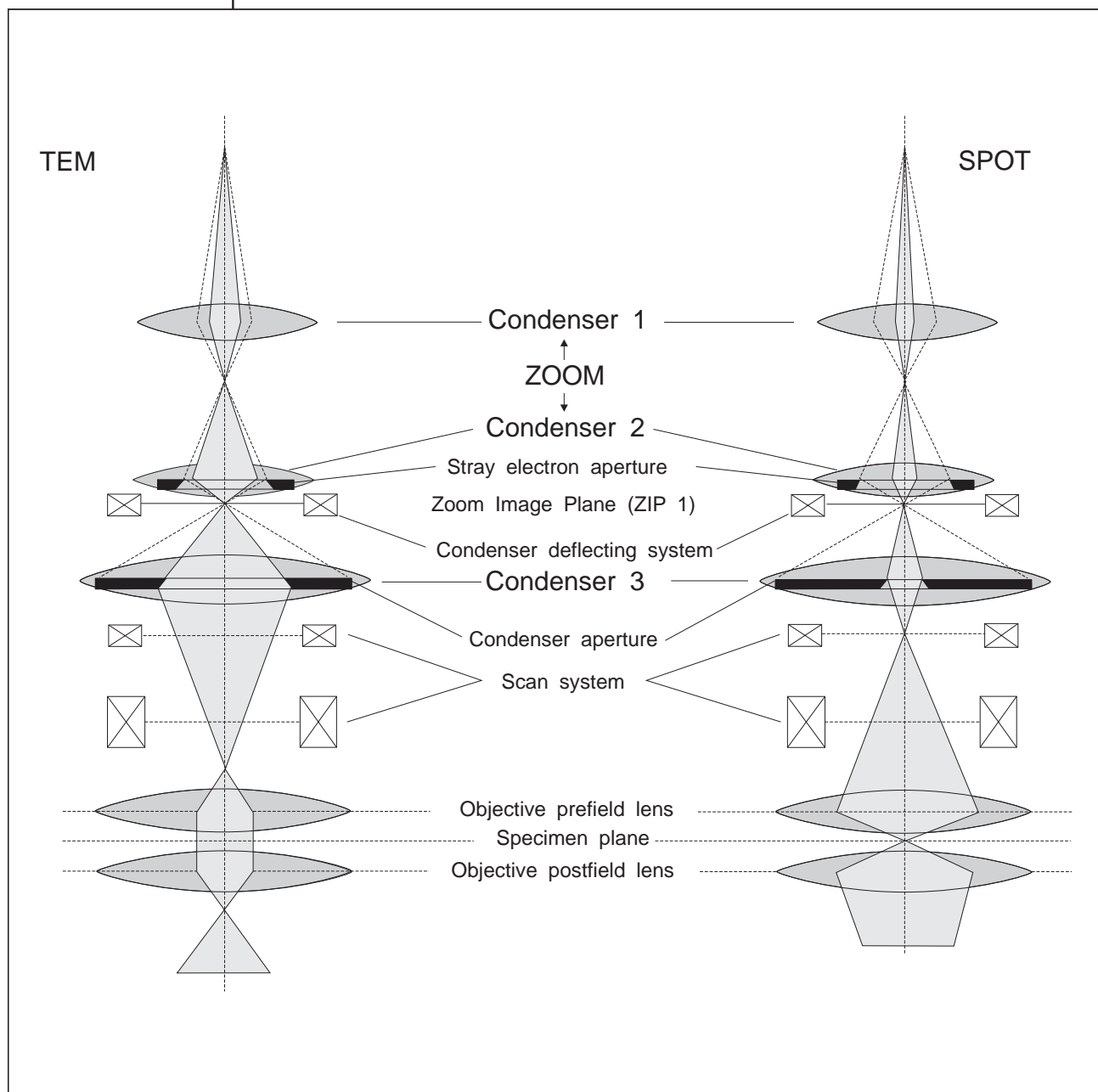
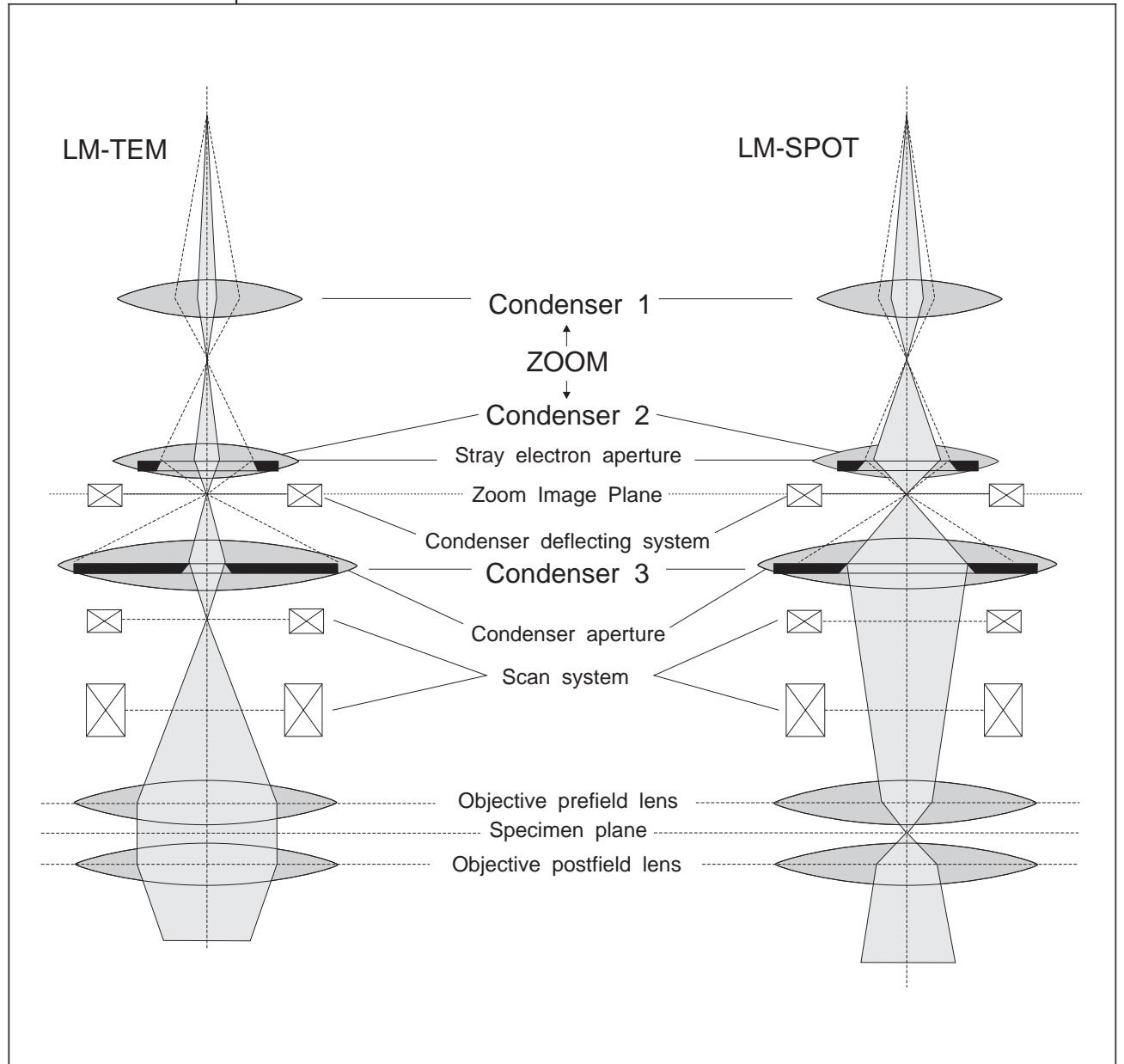


Fig. 1-10: TEM and SPOT illumination, M mode

In *Low Magnification (LOW MAG (LM)) mode* for magnifications from 50x to 1,250x the objective lens operates with a long focal length. The focal point of the objective prefield lens lies in the medium plane of the upper deflecting elements of the Scan System. The 3rd condenser images the crossover image from the zoom image plane (ZIP) in this plane.



Version 3.20

Fig. 1-11: TEM and SPOT illumination, LM mode

Illumination direction**Illumination shift (ILLUMINATION SHIFT)**

A double deflecting system (Scan System) above the objective lens has its transition point in the front focal plane of the objective prefield lens. It allows the illuminating electron beam to be shifted without tilting. Together with TEM illumination it permits among others Minimum Dose Focusing (MDF) in the LEO 912 OMEGA. The method consists in focusing on a specimen spot directly adjacent to the selected specimen area, which prevents damage of the specimen by irradiation. With illumination shift the beam jumps only for the time of exposure to the area selected for photography. In SPOT mode the illumination shift can be used to direct the luminous spot with the scan shift of the Scan System to any specimen spot, thus realizing SCAN mode.

Illumination tilt (ILLUMINATION TILT)

The upper deflecting system of the Scan System has its tilt plane in a conjugate plane of the object plane (objective lens front focal plane). The illuminating electron beam thus passes at an angle through the object plane if only the upper deflecting element is activated.

With an objective lens aperture, the beam tilted this way can produce also darkfield images (DF mode) in TEM illumination. The direction of the incident beam is then adjusted so that the scattered electrons reach a path parallel to the optical axis and thus produce the image. The objective lens aperture will here mask out the non-scattered electrons.

Illumination tilt applied in SPOT illumination allows diffraction examinations using **C**onvergent **B**eam **E**lectron **D**iffraction (CBED).

Fig. 1-12 shows the beam paths of normal, shifted, and tilted TEM illumination. The corresponding beam paths for SPOT illumination are shown in Fig. 1-13.

Independent parallel shift (SHIFT) and tilt (TILT) of the illumination are possible also in LOW MAG mode, but other than in MAG mode

- the shift is effected by the upper deflecting system of the Scan System
- the tilt by both deflecting systems of the Scan System.

The beam paths are shown in Fig. 1-14 (TEM) and Fig. 1-15 (SPOT).

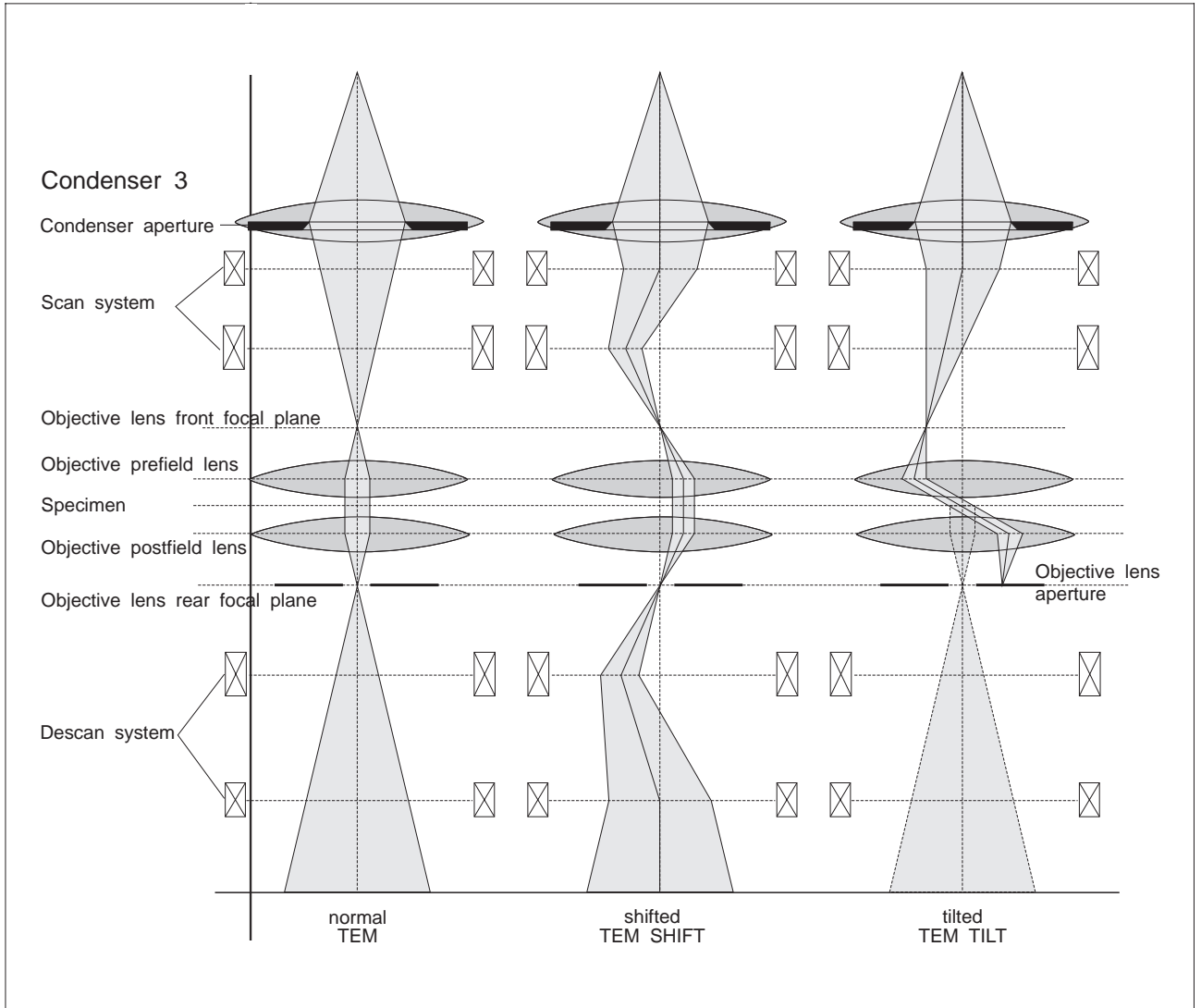


Fig. 1-12: M mode: normal, shifted, tilted TEM illumination

Version 3.20

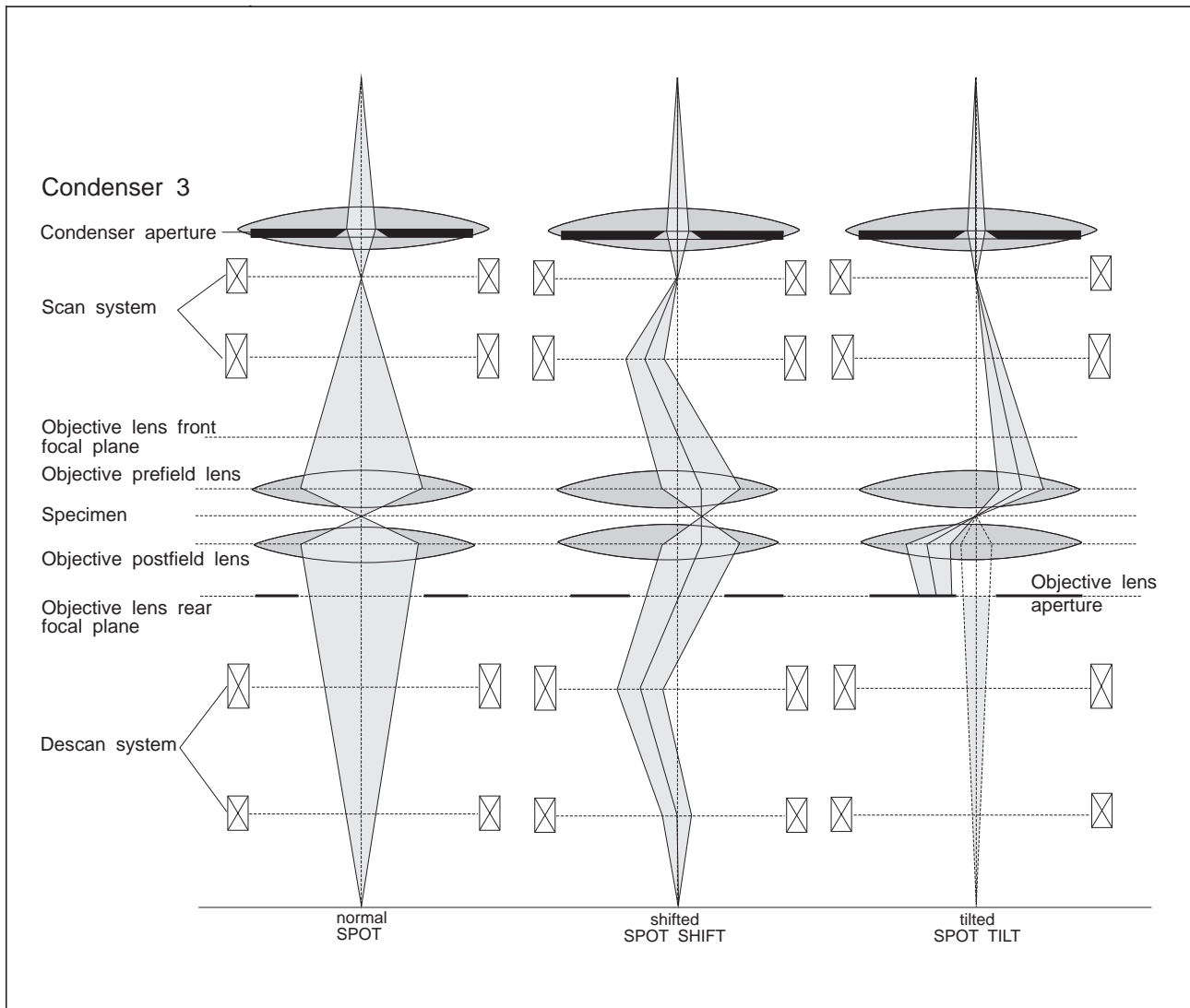
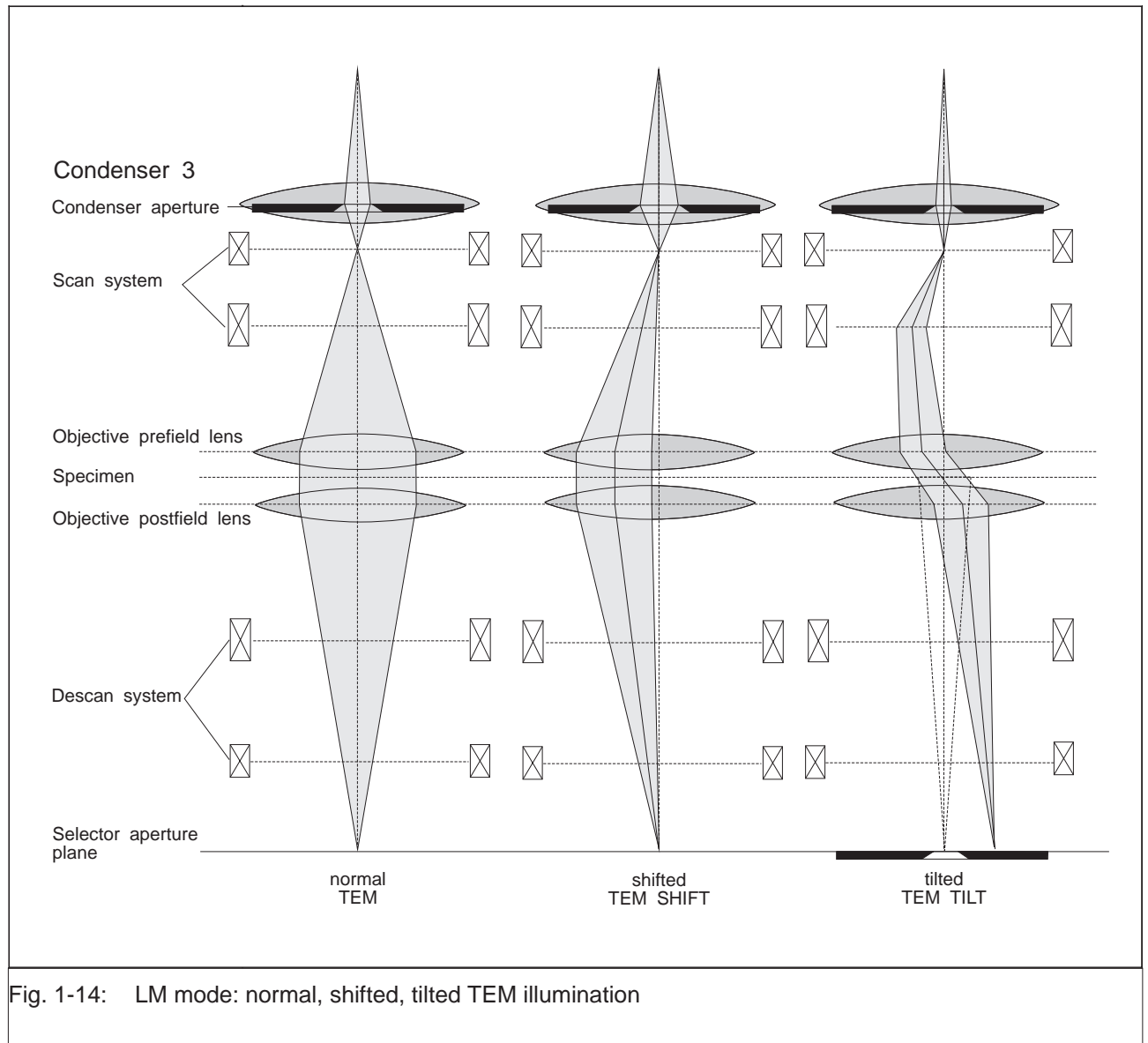


Fig. 1-13: M mode: normal, shifted, tilted SPOT illumination



Version 3.20

Fig. 1-14: LM mode: normal, shifted, tilted TEM illumination

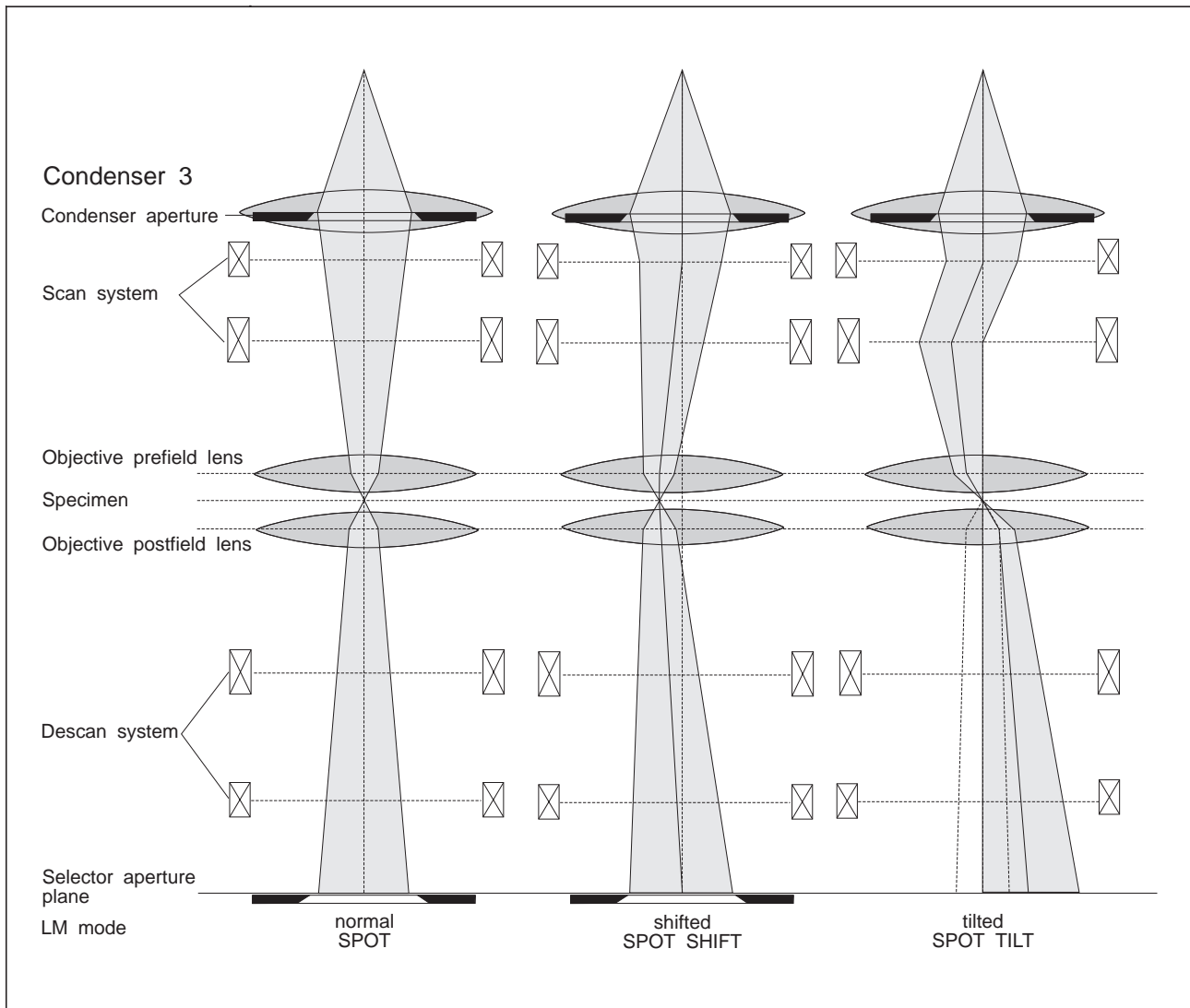


Fig. 1-15: LM mode: normal, shifted, tilted SPOT illumination

Illumination adjustment in MAG mode

Brightness adjustment

The brightness (illuminating aperture or ILL. ANGLE) is adjustable by changing the crossover image with the condenser zoom system. The adjustment is made with the double key ILL. APERTURE / SPOT SIZE in the field BRIGHTNESS, which changes the lens currents of condensers 1 and 2 by the condenser zoom control.

Illumination-aperture selection with TEM illumination and magnifications up to 4,000x

A beam limiting aperture (C2 fixed aperture) with a hole diameter of 225 μm is provided in the principal plane of the 2nd condenser. At magnifications up to 4,000x a 2-step variation of the luminous-field size is achieved with this aperture by changing the zoom image plane (ZIP). The size of the illuminated object plane area varies with the position of the ZIP:

ZIP areas

ZIP	Distance ZIP-C2 (mm)	Magnification range	Luminous-field diameter(μm)
2	8	2,000 to 3,150	80
1	16	as of 4 000	40

Fig. 1-16 shows schematically the variation of the luminous-field size as a function of the ZIP.

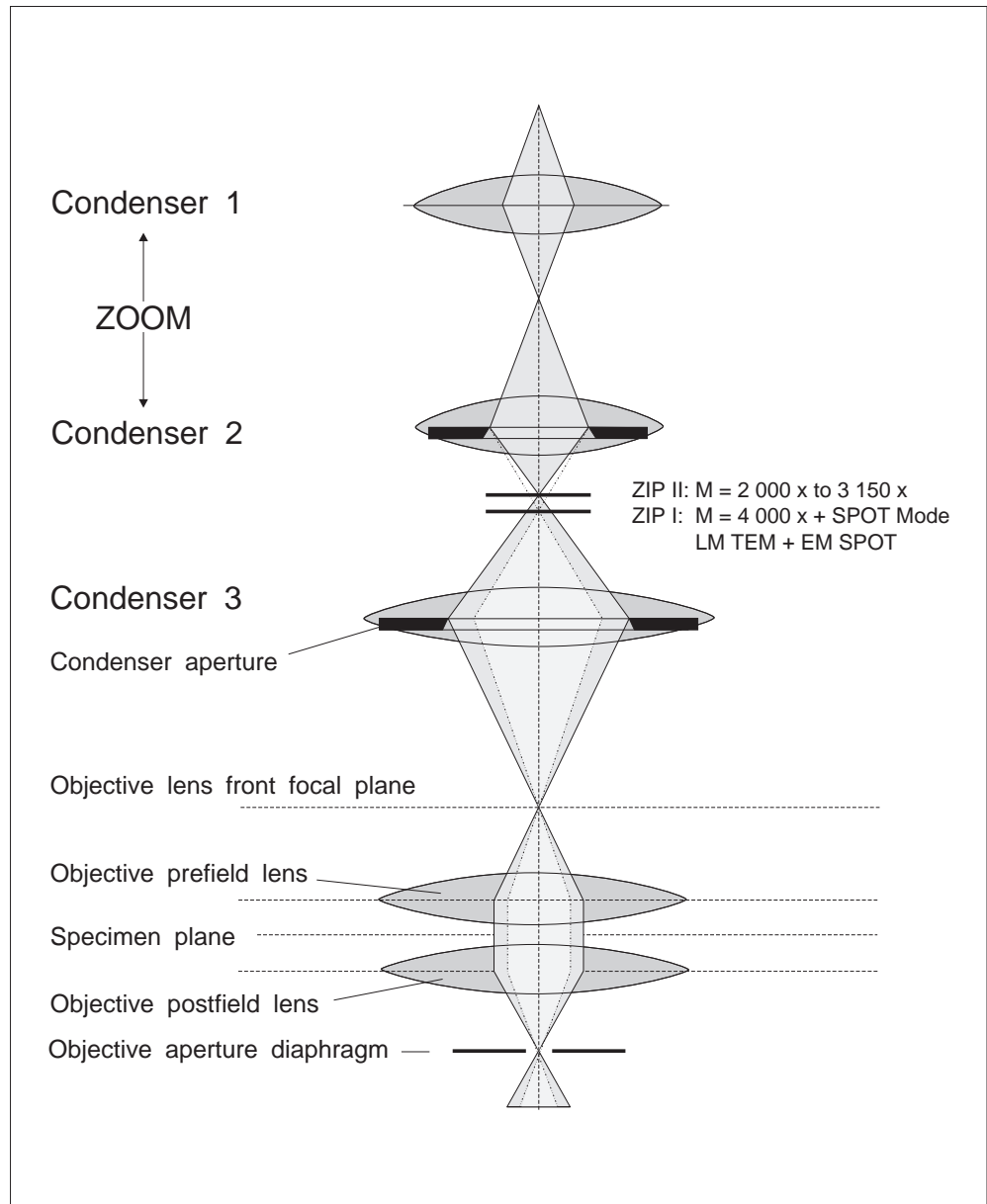


Fig. 1-16: Change of luminous field size as a function of ZIP

Illumination-aperture selection with TEM illumination and magnifications from 6,300x (AIS mode)

The LEO 912 OMEGA offers three possibilities of illumination-aperture selection:

- Manual change of condenser aperture (= luminous field aperture)
- Electronic change of AIS aperture with automatic aperture selection as a function of the adjusted magnification (**A**utomatic **I**llumination-aperture **S**election (AIS) mode)
- Electronic change of AIS aperture with aperture selection by the user (**M**anual **I**llumination-aperture **S**election (MIS) mode)

In AIS or MIS mode the condenser deflecting system directs the beam to either one of 5 differently sized openings of a multi-hole aperture (Fig. 1-17). The 5-hole aperture is arranged in the principal plane of the 3rd condenser lens. The 3rd condenser lens images the crossover in the front focal point of the objective prefield lens. The Scan System operates synchronously with the condenser deflecting system and deflects the beam after passing through the aperture back to the optical axis.

The beam path for AIS and MIS modes is shown in Fig. 1-18 for on-axis and off-axis aperture positions.

The assignment of magnification and AIS aperture is as follows:

AIS aperture	Diameter of opening (μm)	Magnification range
0	37	LM mode and 3,150x (AIS off, multi-hole aperture removed!)
1	600	4,000x to 12,500x
2	300	16,000x to 25,000x
3	150	31,500x to 50,000x
4	75	63,000 to 100,000x
0	37	as of 125,000x
0	37	Spot mode

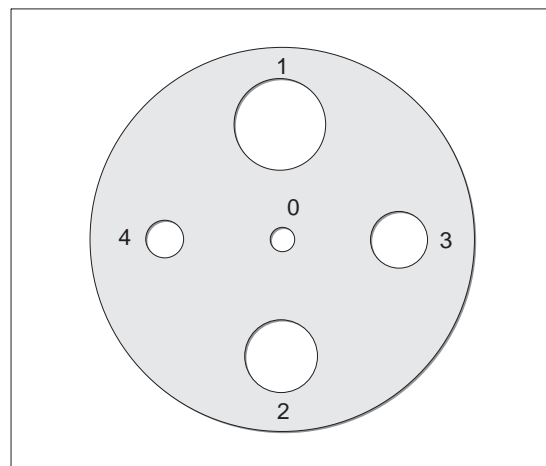


Fig. 1-17: 5-hole aperture (AIS aperture)

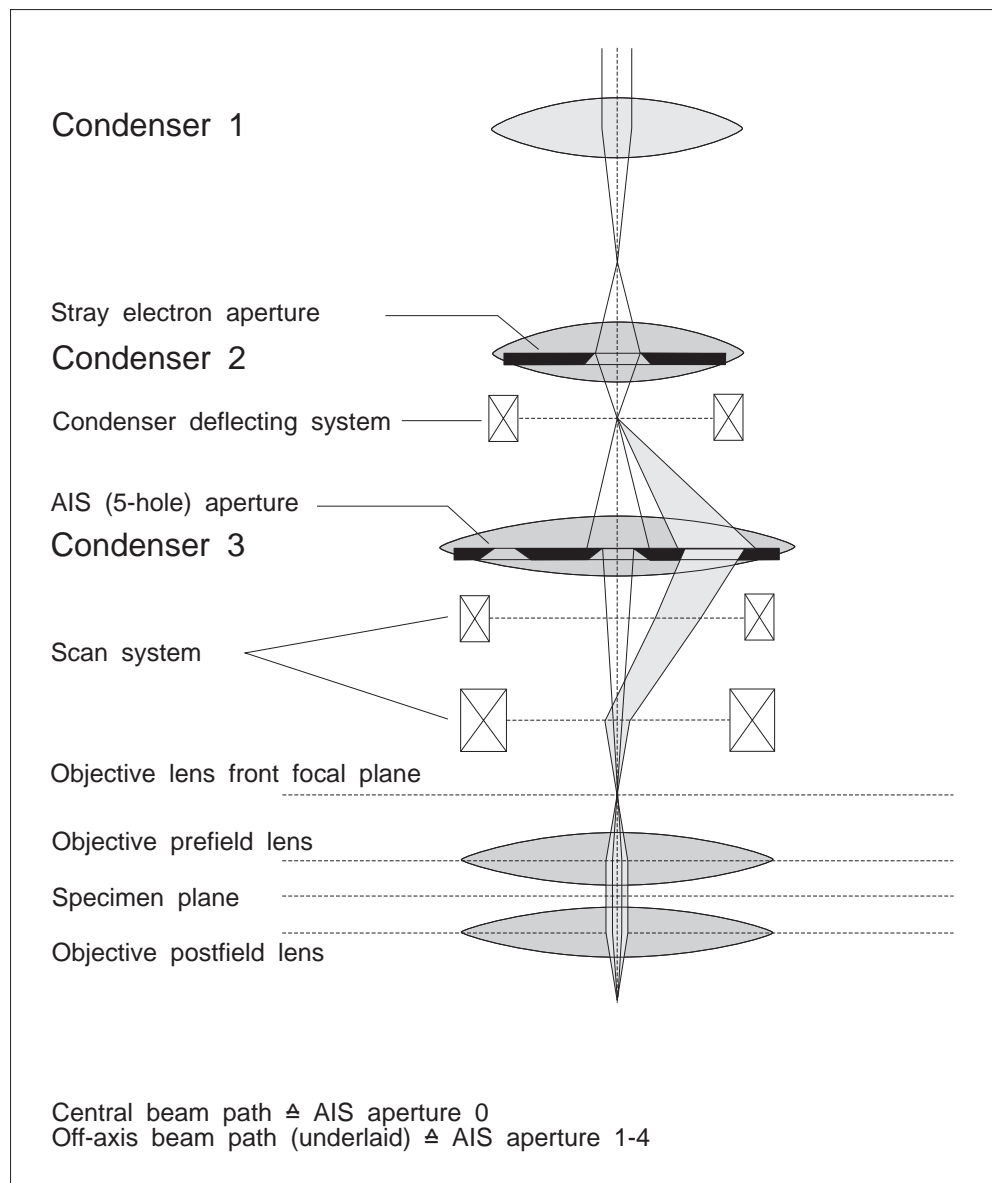


Fig. 1-18: Beam path in AIS mode

AIS control

Fig. 1-19 displays the AIS beam path and the AIS control.

The AIS control unit serves to select the condenser deflecting system and synchronize it with the Scan System control. The latter joins the static values of illumination tilt and shift with the offset values of the selected AIS aperture. It also controls the power supplies for the upper and lower deflecting elements of the Scan System.

In AIS mode the beam passes obliquely through the 3rd condenser (C3). The excitation of the condenser stigmator is, therefore, adjusted depending on the AIS aperture. The condenser stigmator control is connected with the AIS control unit for this purpose. Separately for each AIS aperture a tilt correction of deflection and lens aberrations is required, which becomes effective through the Scan System control.

The stigmator values and the values of illumination tilt and shift are entered in the menu AIS ADJUST by the encoders X and Y in the control field ILLUMINATION.

In AIS mode the C3 fine current value is set by turning the encoder SPOT FOCUS fully counterclockwise; the setting is invariable because the excitation of C3 influences the direction of irradiation.

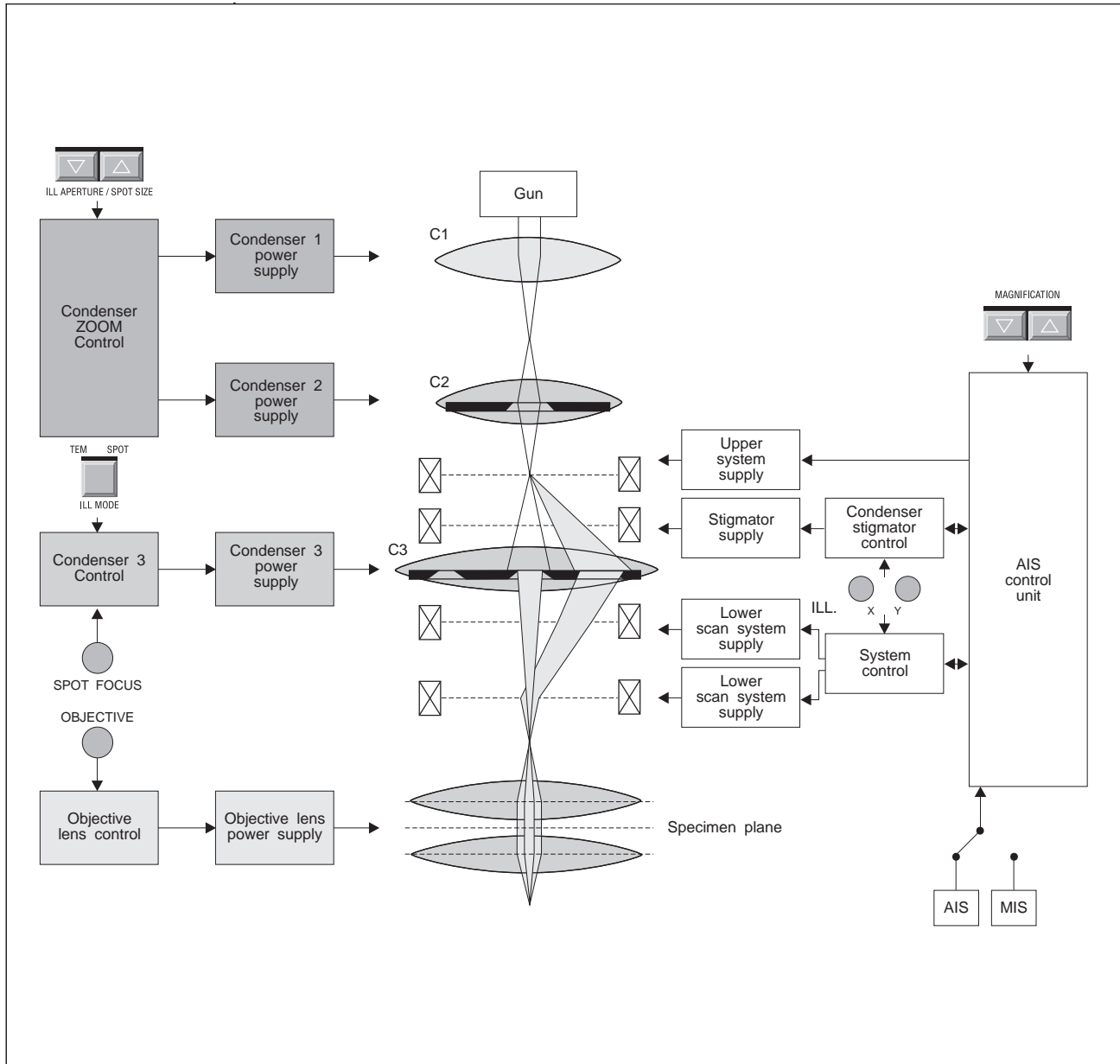


Fig. 1-19: AIS beam path and AIS control

SPOT illumination

In SPOT illumination mode ZIP 1 is selected and AIS mode deactivated (AIS 0); the beam passes through the central opening of the 5-hole aperture which then acts as aperture diaphragm for spot imaging (see Fig. 1-15). The last value of the C3 current adjusted in SPOT mode is used. The current is variable within a wide range by the encoder SPOT FOCUS. With the key CALIBRATE, C3 current and objective lens current can be reset to the value for the eucentric axis.

The condenser zoom steps in TEM and SPOT modes are adjusted and stored separately. The user can thus change from widefield illumination with defined brightness to SPOT illumination with defined spot diameter by simply pushing a button. The brightness in TEM mode or the spot diameter in SPOT mode are variable by changing the condenser zoom step with the double key ILL. APERTURE / SPOT SIZE. In SPOT mode there are four additional zoom steps 1 to 4. The spot aperture depends on the selected condenser aperture.

Illumination adjustment in LOW MAG (LM) mode**TEM illumination**

The maximum diameter of the illuminated object area is determined by the fixed aperture in the principal plane of the 2nd condenser. The diameter is approx. 2mm and may be limited to a smaller value by a suitable condenser aperture.

The brightness is variable by changing the crossover demagnification with the condenser zoom system. The condenser zoom steps are separately adjusted and stored in MAG and LOW MAG modes.

SPOT illumination

Like in MAG mode the C3 current is variable within a wide range. The actual C3 SPOT current value for LM mode is output.

The luminous spot can be narrowed to a minimum size by focusing C3.

The two illumination modes TEM and SPOT can be combined with the two magnification modes MAG and LOW MAG (Fig. 1-20).

In MAG mode there are two constant zoom image planes, ZIP 1 and 2. In ZIP 1 the electron beam can be guided on axis and off axis with the AIS apertures 1 to 4.

All other combinations are possible only with deactivated AIS (AIS 0).

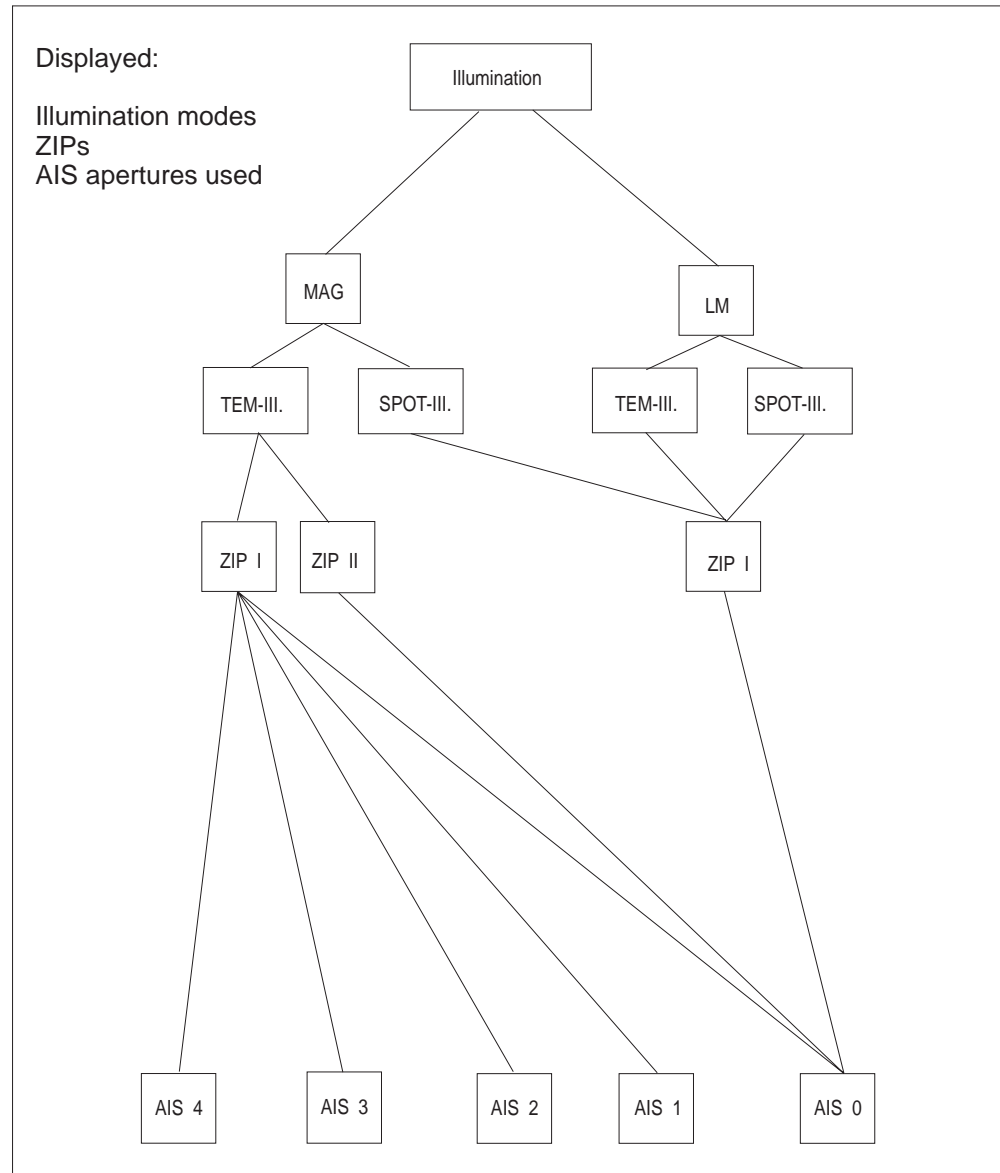


Fig. 1-20: Block diagram of illumination system

HR mode (High-resolution mode)

To minimize the energy spread in the illumination system (Boersch effect), the beam path for high resolution should be selected so that the illuminating aperture is adjusted with a minimum of intermediate images of the crossover (CO). The LEO 912 OMEGA offers for this task the HR mode with only one CO image in the front focal plane of the objective prefield lens (OPF) (Fig. 1-21a). In this mode the CO of the gun is imaged for illuminating apertures $\sigma \geq 1.6\text{mrad}$ in the front focal plane of the OPF lens without intermediate image, by C1 and C3 alone. Only AIS 0 is possible and useful in this case.

SPECIAL NOTE:

Köhler illumination is realized also in HR mode, because the source (CO) is imaged in the focal plane of the last condenser lens (OPF), and the OPF lens images at the same time the condenser (luminous-field) aperture in the object plane.

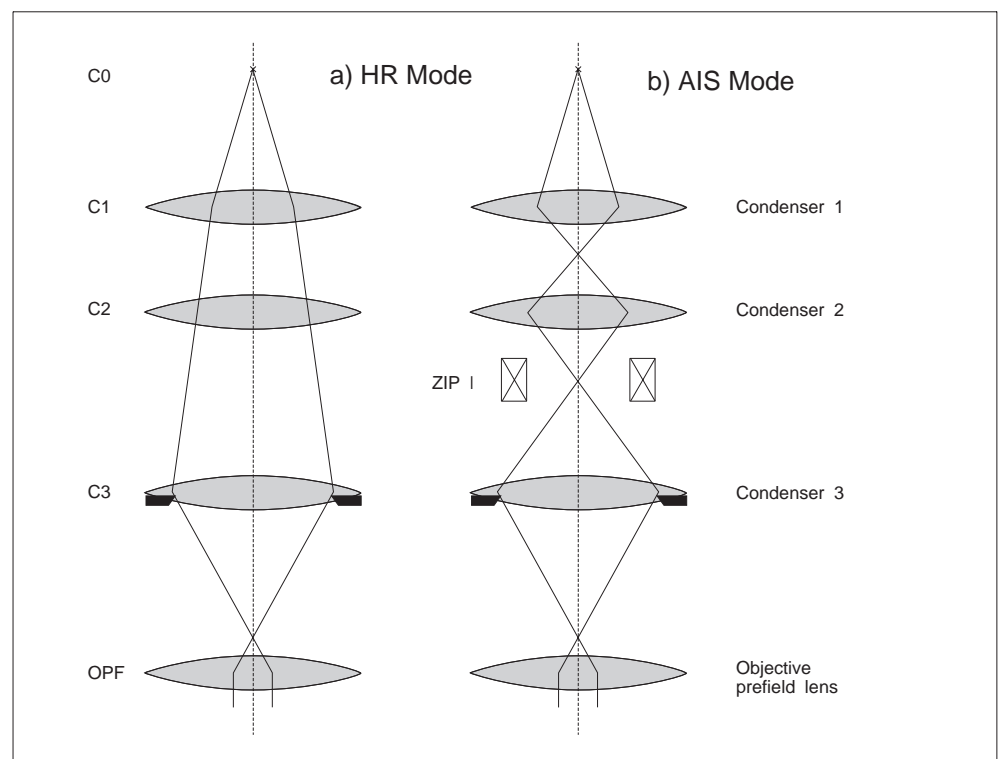


Fig. 1-21: HR Mode

The imaging system

The imaging system includes these four principal components:

- Objective lens
- first projector lens system
- Omega energy filter
- second projector lens system

Objective lens

The objective lens is a Riecke/Ruska condenser/objective single-field lens, with the object in its geometric center. The lens has two functions:

- The upper part, the objective prefield lens, acts as fourth condenser lens. According to the Köhler illumination principle it bundles the incident electrons paraxially on the specimen in TEM mode, and focuses them vertically incident on the object plane in SPOT mode.
- The lower part is the objective lens proper. It operates at fixed excitation so that the focus is maintained during magnification change (Parfocal Imaging System).

The symmetrical design of the objective lens and Köhler illumination provide for optimal imaging, diffraction, and analysis conditions. The specimen always remains in the same position in the geometrical center of the pole piece gap to which the eucentric axis of the specimen stage is also aligned. The objective lens can be automatically calibrated to eucentric position at the touch of a button.

There are two operating modes of the objective lens:

(a) Short focal-length mode

Features:

- 3.6mm focal length (high excitation of objective lens)
- Diffraction image in plane of objective lens aperture diaphragm
- Real object image in selector aperture plane
- Total magnification range: 3,150x to 500,000x

(b) Long focal-length mode

Features:

- 90mm focal length (low excitation of objective lens)
- Diffraction image in plane of selector aperture acts as aperture diaphragm
- No real object image produced by the objective lens alone
- Total magnification range: 80x to 2,000x

First projector lens system

The first projector lens system provides for the desired total magnification of the object area or the diffraction pattern of the imaged object area produced by the objective lens, thereby considering the requirements of the energy spectrometer.

The correct transmission of the first intermediate image or the diffraction image produced by the objective lens into the imaging energy filter requires a projector lens system of three independent lenses.

Tasks of the system in imaging mode:

- Variable magnification in the range from 80x to 500,000x
- Imaging the rear focal plane of the objective lens in the entrance pupil plane of the spectrometer
- Imaging the first intermediate image plane into the entrance image plane of the spectrometer.

Tasks of the system in diffraction mode:

- Variable camera length in the range from 300mm to 800mm
- Imaging the first intermediate image plane into the entrance pupil plane of the spectrometer
- Imaging the diffraction pattern in the rear objective lens focal plane in the entrance image plane of the spectrometer

The entrance pupil plane (plane of the entrance crossover) and the entrance image plane of the omega filter are fixed. The first projector lens system is therefore a zoom system which automatically provides for imaging in these planes.

Omega spectrometer

The imaging omega energy spectrometer generates in its exit image plane an achromatic 1:1 image of its entrance image plane. All electrons from one object (or diffraction) point are focused in one image point in the achromatic plane (spatial focusing).

The omega filter produces at the same time in the spectrum (energy-dispersive) plane a spectrally dispersed 1:1 image of its entrance pupil. All electrons of equal energy but from different object or diffraction points are focused in one point in the spectrum plane (energy focusing). The orbits of electrons with different energy have different directions in the achromatic image plane (directional focusing). This yields in the energy-dispersive plane an electron energy loss spectrum (EELS) of the viewed object area or diffraction pattern. Defined-energy electrons can be selected from the achromatic image by a slit aperture. The width of the analyzer slit defines the energy resolution of the image.

The analyzer slit lies exactly on the optical axis of the microscope. To select a specific electron energy for specimen or diffraction spectrum imaging, not the analyzer slit is moved, but the primary electron energy raised by a specific amount which exactly corresponds to the energy loss of the specimen you want to know. With this method the orbit of the selected energy loss electron is always exactly axial, with constant excitation of the imaging system and energy spectrometer, and constant position of the analyzer slit. The energy range is selected either manually by pushing a button or automatically controlled by the computer, in digital increments of 0.2eV. The excitation of the illumination system is automatically adjusted so that all illumination parameters are maintained.

The dispersion of the omega spectrometer in the slit plane is approx. $1\mu\text{m}/\text{eV}$ at 120keV electron energy.

Second projector lens group

The second projector lens group consists of two lenses. At variable magnification it images either the achromatic image plane or the spectrum plane on the recording system of the LEO 912 OMEGA. This enhances considerably the imaging and analysis capability of the energy-filter TEM, compared with conventional TEMs.

Operating modes

The imaging and diffraction modes are displayed in Fig. 1-22. In LOW MAG mode the objective lens is weakly excited, in MAG and HIGH MAG modes it is highly excited.

Imaging or diffraction mode is adjusted by the first projector lens system, and the corresponding image or diffraction pattern transmitted to the omega filter. The second projector lens system sets either the filter imaging or spectrum mode, and transmits the energy-filtered image (or diffraction pattern) or its EEL spectrum to the recording system. The correlation is shown in Fig. 1-23.

Lens programs

There is a lens program for each step of the adjustable accelerating voltage (60, 80, 100, 120kV). The user cannot change the optimized programs.

With the option FREE LENS CONTROL the user can set up max. four imaging programs, e.g. copy one of the given lens programs and change it to suit his own requirements.

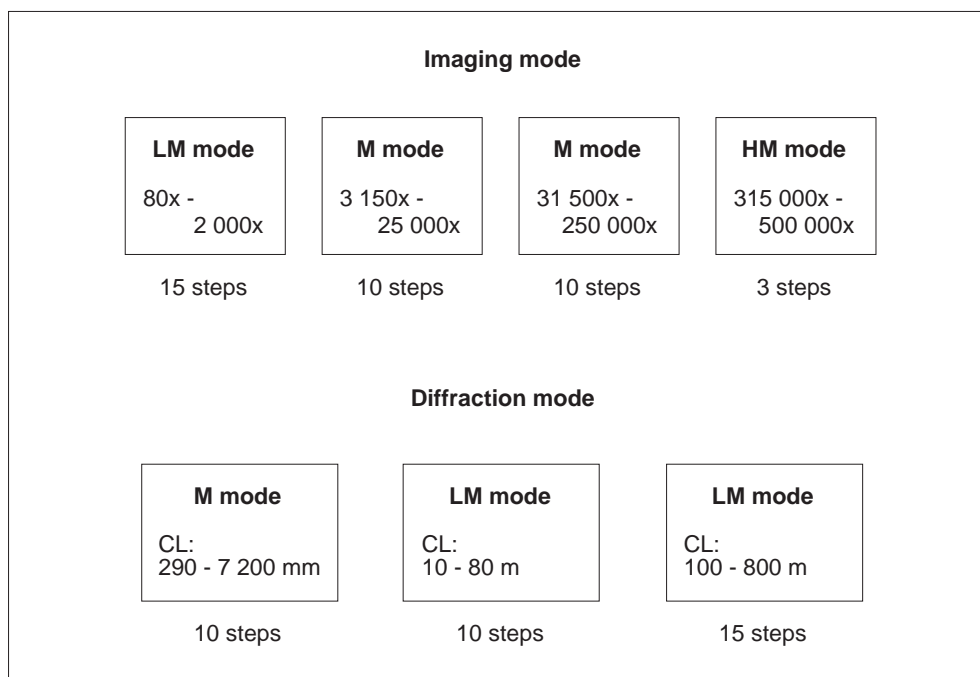


Fig. 1-22: Imaging and diffraction modes

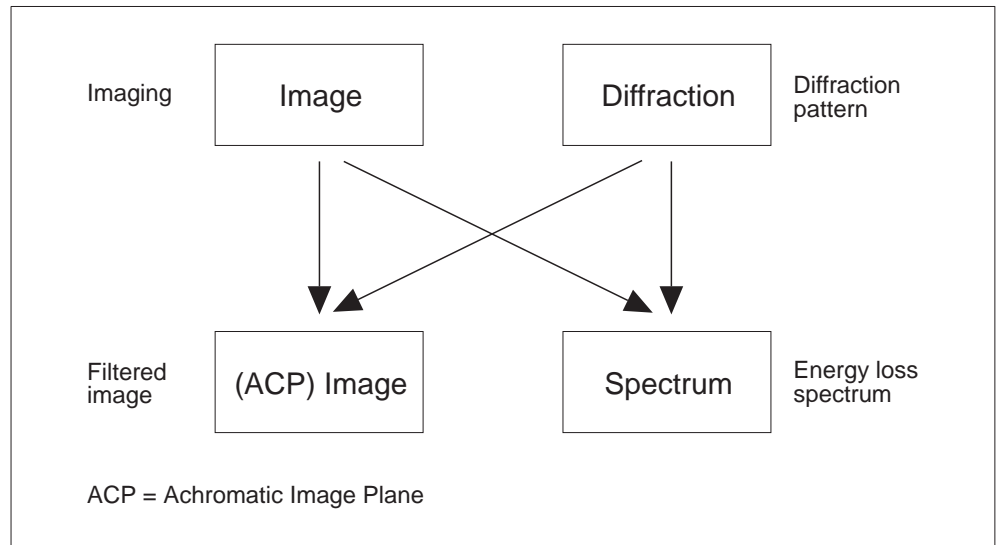


Fig. 1-23: Possible final images

Magnification

The zoom program of the imaging system allows 25% magnification steps by corresponding selection of current values and current direction in the lenses.

Fig. 1-22 lists the number of steps available in the different imaging and diffraction modes. With installed option FREE LENS CONTROL other steps can be keyed in from the keyboard.

Beam paths

Figs. 1-24, 1-25 and 1-26 show the schematic beam paths in the different imaging modes. Objective lens and projector lens are separately controlled.

Magnification change in IMAGE mode or change of camera length in DIFFRACTION mode normally changes only the excitation of the projector lenses. The objective lens focus is exactly maintained (Parfocal Imaging System). Only switching between MAG and LOW MAG modes activates the objective lens from the lens program and switches it from high to low excitation.

Focusing is generally made by varying the objective lens excitation. The focus conditions are selectable in the menu FOCUS PARAMETERS. A wobbler (AID) is available for focusing. The focus is adjusted to the eucentric axis of the specimen stage by pushing the key CALIBRATE.

HIGH MAG mode for magnifications from 315,000x provides for extremely high excitation of projector lens 1. The user must then adjust the objective lens to the entrance image plane of the first projector lens.

Projector lens 1 serves for focusing in DIFFRACTION and LOW MAG IMAGE modes.

Fig. 1-24 displays the beam paths for ESI (Electron Spectroscopic Imaging) mode, Fig. 1-25 for ESD (Electron Spectroscopic Diffraction). In both modes the second projector lens system images the achromatic image plane 90x magnified in the sheet-film plane.

Fig. 1-26 shows the beam path in the second projector lens system when changing from (ACP) IMAGE mode to SPECTRUM mode. Re-enlargement of the EEL spectrum is possible from 40x to 315x.

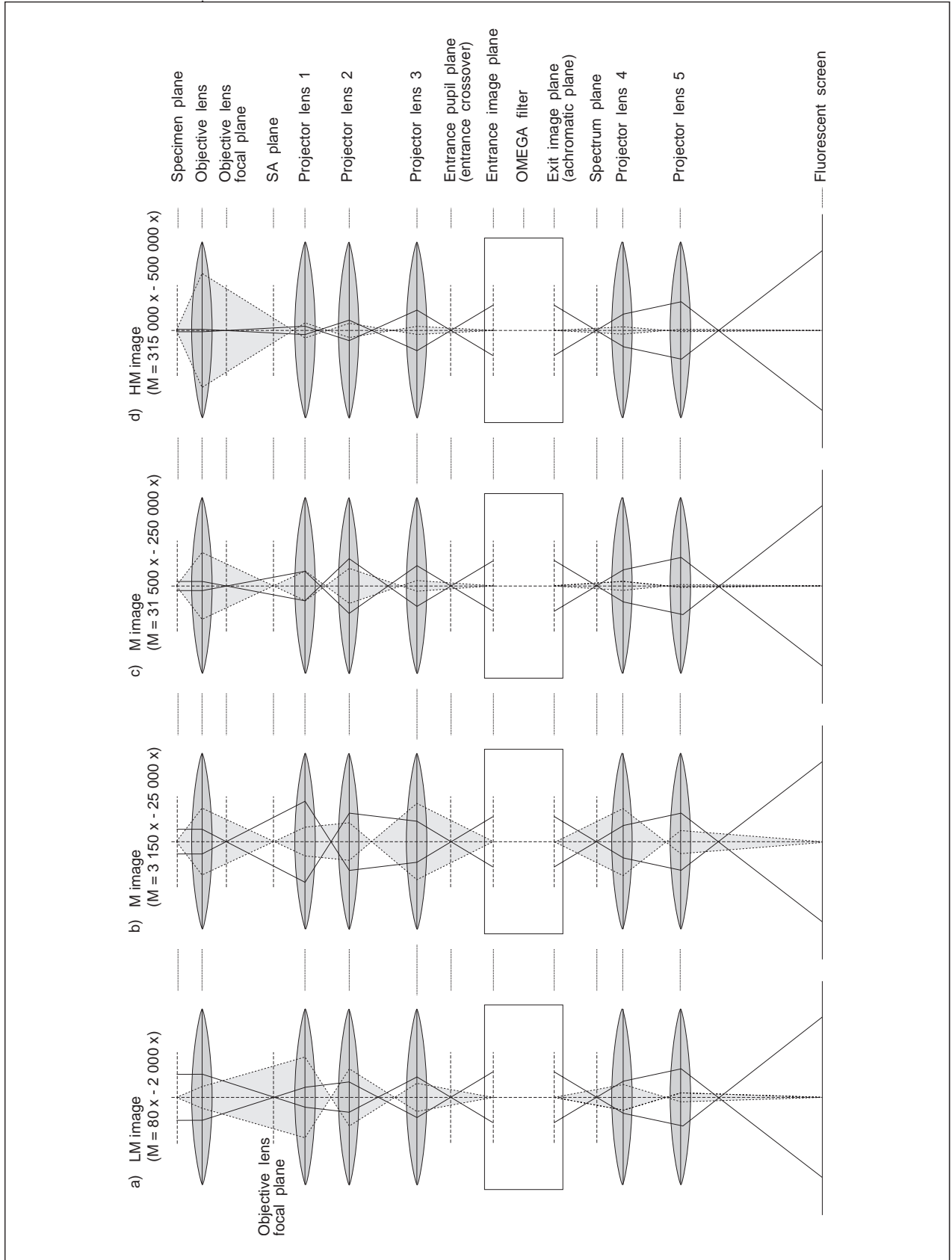


Fig. 1-24: Beam paths of imaging systems in MAG mode

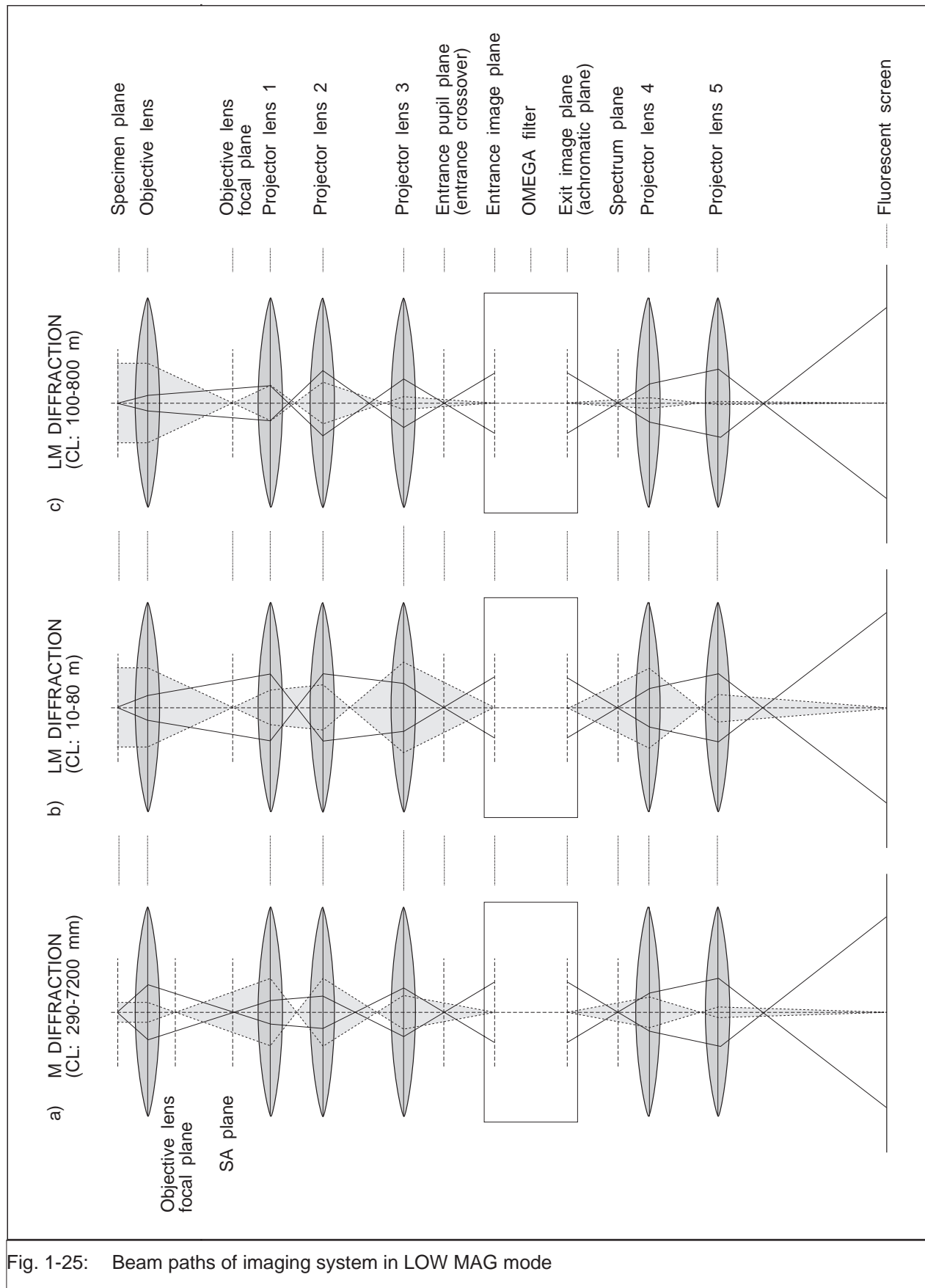


Fig. 1-25: Beam paths of imaging system in LOW MAG mode

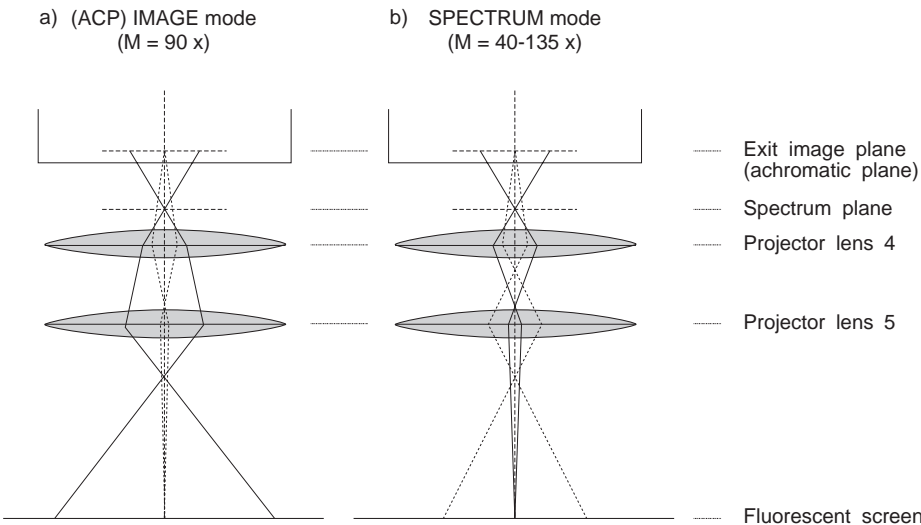


Fig. 1-26: Beam paths in 2nd projector lens system

Version 3.20

1.2.3**Vacuum system**

The differential pump system of the LEO 912 OMEGA produces a clean vacuum.

The electron-optical column (Fig. 1-27) is evacuated by two high-vacuum pumps. An ion getter pump (IGP1) continuously evacuates specimen (2) and filament (1) chambers, even if the key switch is in OFF position (overnight service). A differential (pressure stage) aperture below the third projector lens (3) isolates the vacuum chamber from the lower column part. If necessary, e.g. for ventilation of one vacuum chamber or in overnight service it is isolated by the pneumatically controlled valve V3.

The lower half of the column which includes the omega spectrometer, second projector lens system intermediate tube, viewing tube and camera chamber (4) is evacuated by a turbomolecular pump (TMP).

The prevacuum for the TMP is generated by a two-stage rotary pump (RP). During lock-in/out it also evacuates the airlock chamber. The incorporation of a bakeable adsorption trap in the prevacuum line is optional.

Fig. 1-28 shows the vacuum system schematically.

There are two options for evacuation of the filament chamber:

- a nitrogen-cooled cryotrap (see Fig. 1-28a), or
- an additional ion getter pump (IGP2) with isolating valves. This option is required for operation of an LaB₆ filament (see Fig. 1-28b).

Version 3.20

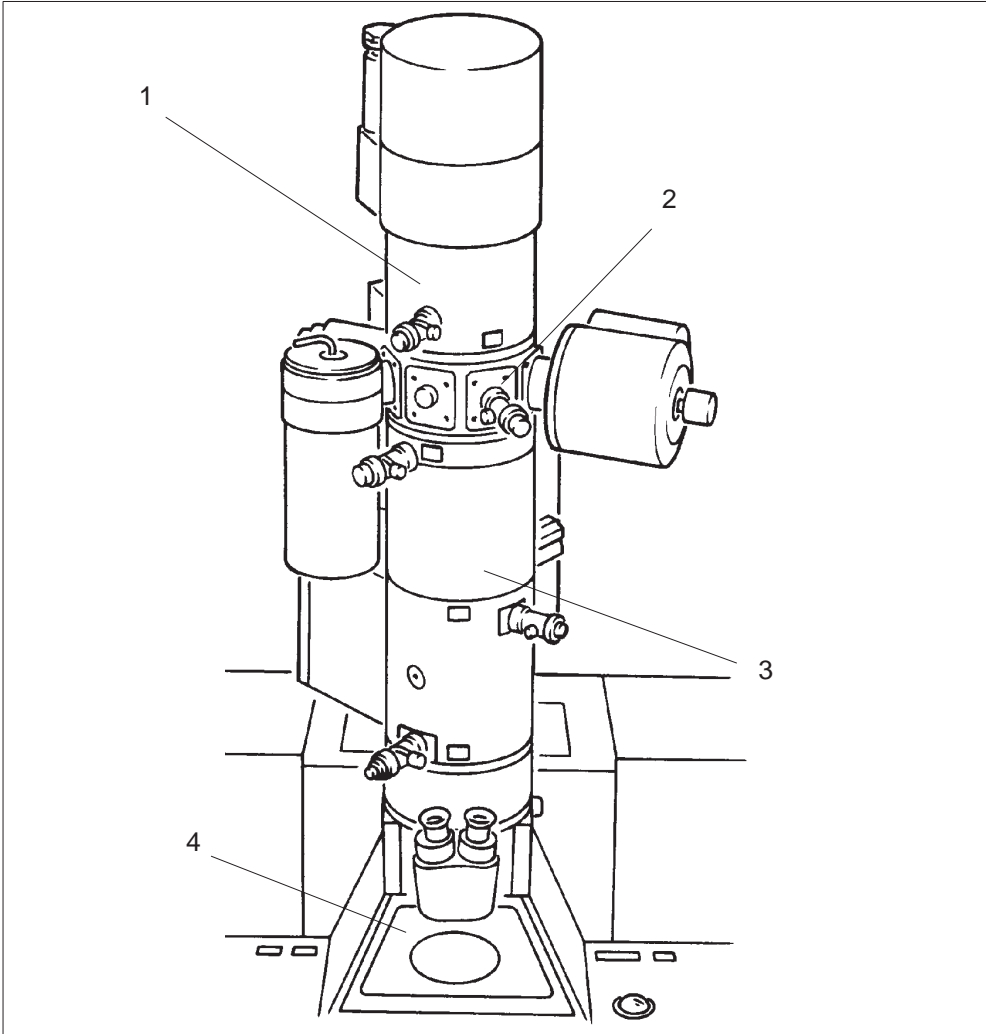


Fig. 1-27: Electron-optical column

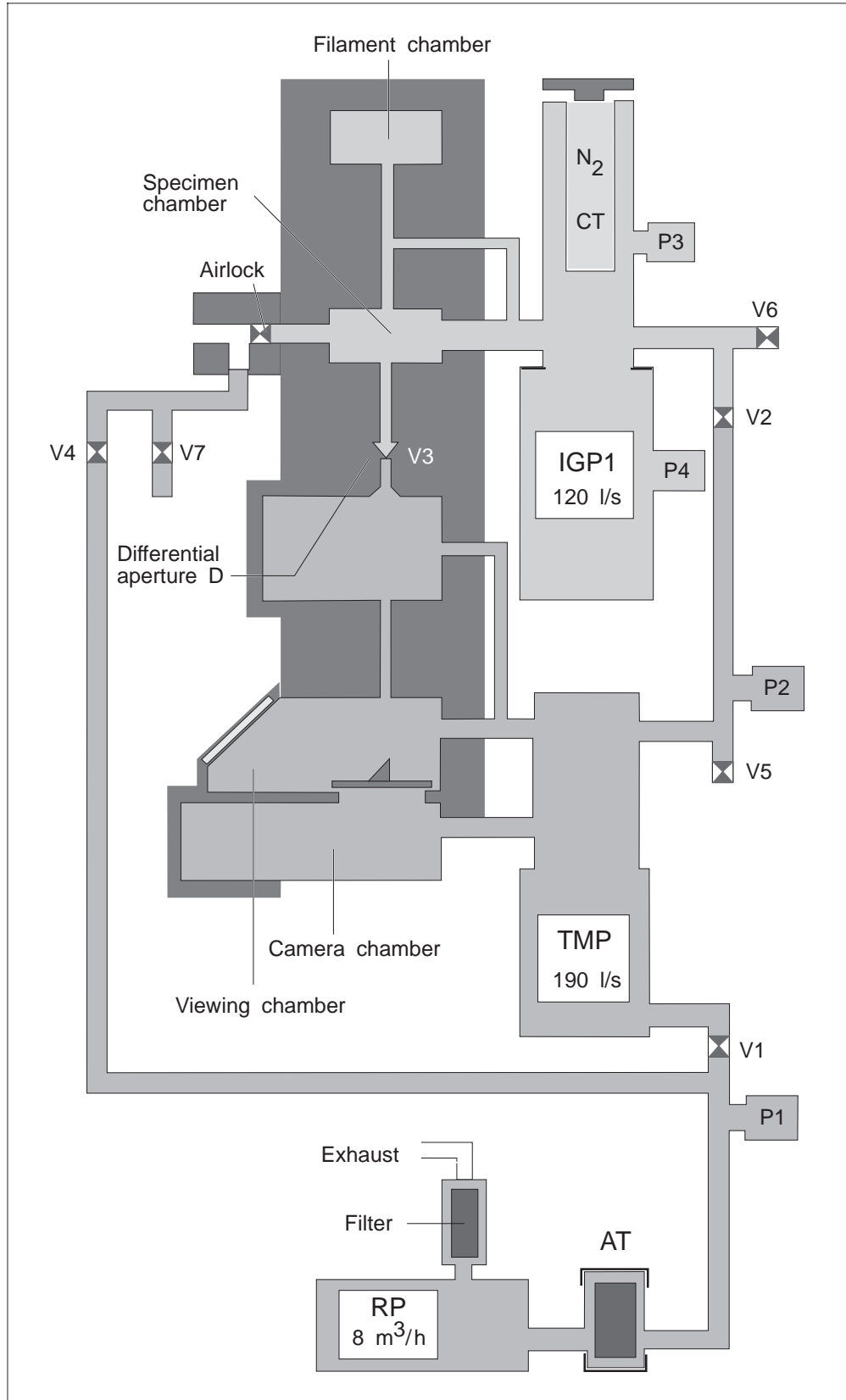


Fig. 1-28a: Vacuum system, pump system with cryotrap

Version 3.20

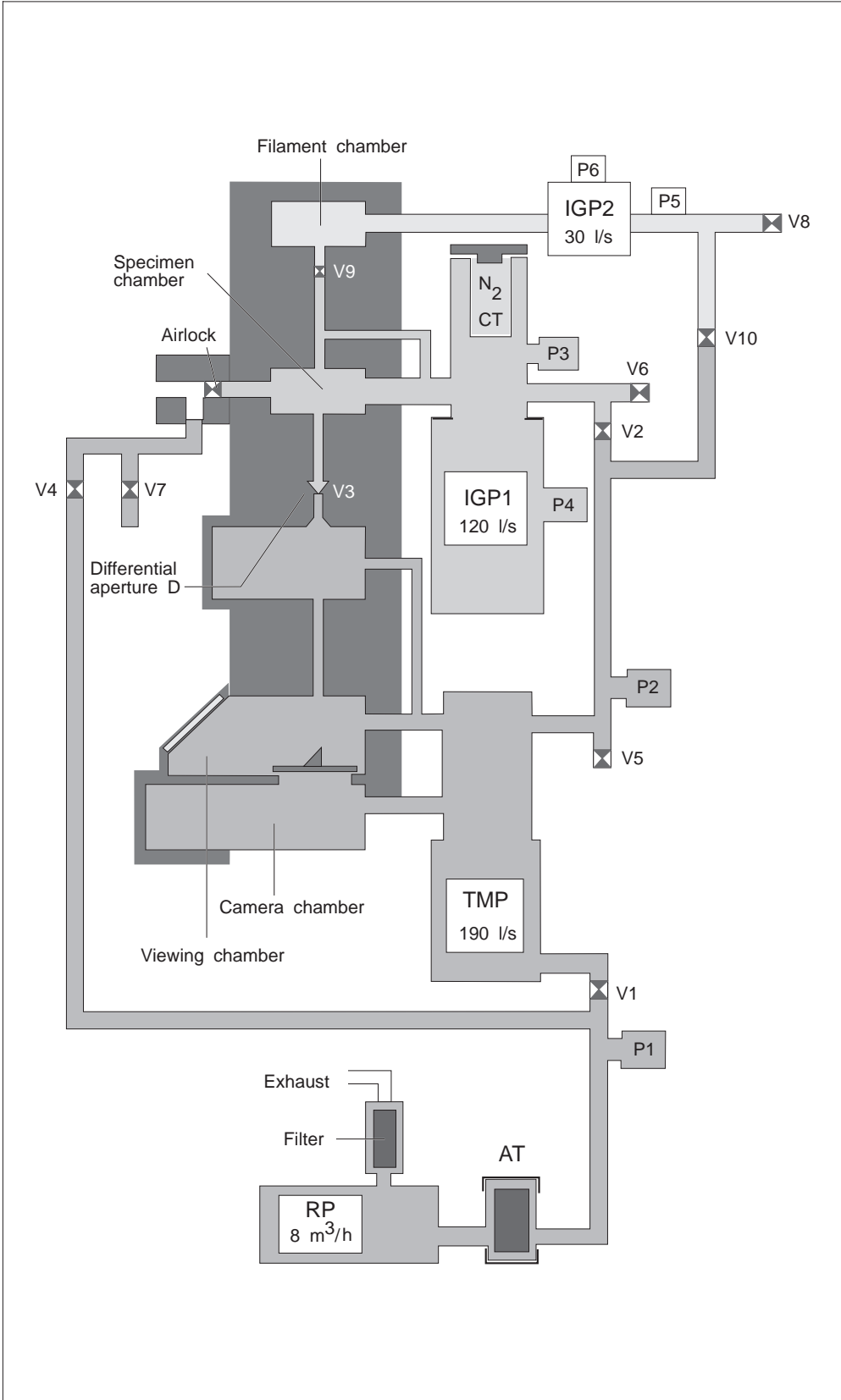


Fig. 1-28b: Vacuum system with option "2nd ion getter pump"

- IGP1 Ion getter pump**
 produces the high vacuum.
 Operating principle: Titanium evaporation
 Suction capacity: 120 l/s
 Final vacuum: $< 2 \times 10^{-7}$ hPa
- CT Cryotrap (Cryotrap)**
 Pump column cooling trap (option)
 supports the IGP1 for operation of the optional cryotransfer system.
- TMP Turbomolecular pump**
 evacuates the lower column part and produces the start vacuum for IGP 1 and optional IGP2.
 Operating principle: a turbine compresses the gas to be pumped down from high-vacuum to prevacuum pressure.
 Suction capacity: 190 l/s
 Final vacuum: $< 5 \times 10^{-5}$ hPa
- RP Rotary pump**
 pre-evacuates the ventilated column and produces the prevacuum for TMP and specimen airlock.
 Operating principle: two-stage vane-type rotary pump
 Suction capacity: 8 m³/h
 Final vacuum: $< 1 \times 10^{-2}$ hPa
- AT Adsorption trap (option)**
 provides in addition for oil-free prevacuum.
 The pump time for lock-in/out is extended by the factor 2.
- V1 Angle valve between RP and TMP**
- V2 Angle valve between TMP and IGP**
- V3 Isolating valve between upper and lower part of the column**
 for separate ventilation of column and camera chambers.
- V4 Airlock valve**
- V5 Ventilating valve for camera chamber**
 for ventilation of camera chamber during film exchange.
 A reducing valve connects V5 and V6 with a cylinder containing pre-dried, clean nitrogen.
 Ventilation and nitrogen flushing considerably reduce the pump-down time.
- V6 Ventilating valve for specimen and filament chambers**
 to ventilate the column, e.g. for filament exchange (VENT GUN function)
 – Nitrogen flushing of column (100 hPa) when the vacuum system is shut down (main switch OFF) or in case of power failure.
- P1 Prevacuum measuring tube**
 Pirani system, measures the prevacuum produced by the RP.
- P2 High-vacuum measuring tube for camera chamber**
 Penning system.
- P3 Prevacuum measuring tube for specimen chamber**
 Pirani system.
- P4 High-vacuum measurement for specimen and filament chambers**
 measures the vacuum produced by IGP1.
- D Differential aperture 1000 μ m (pressure-stage aperture)**
 separates the specimen from the camera chamber.
- V7 Flushing valve (option) for nitrogen flushing of airlock.**

Additional components of optional pump system for filament chamber (second ion getter pump)

IGP2 Ion getter pump

Suction speed: 30 l/s

V8 Flushing valve for filament chamber

V9 Isolating valve between filament and specimen chambers

V10 Isolating valve between TMP and IGP2

P5 Prevacuum measuring tube for IGP2
Pirani system.

P6 High-vacuum measurement for filament chamber
measures the vacuum produced by IGP2.

1.2.4

Anticontaminator

The optional anticontaminator (Fig. 1-29) for the LEO 912 OMEGA is mounted on one of the flanges in the middle of the column. It consists of a metal body which encloses the object. Because of the design the object "sees" as much as possible of its surface (cryopump principle). The metal body is cooled down to a temperature of approx. 100 K by heat dissipation from the outside, so that residual molecules from the specimen chamber will condense. This brings the following effects:

- The specimen chamber is contaminated less by residual molecules
- The vacuum is improved

For thermal conductivity the cooling surface is connected with an approx. 20 mm thick copper rope on the outside of the flange, which is hanging in a thermos vessel filled with liquid nitrogen (Dewar vessel). The Dewar vessel must be regularly refilled because the liquid nitrogen evaporates by taking up heat from the specimen chamber and the environment.

One charge of approx. 1 l liquid nitrogen is sufficient for approx. 6 hours.

CAUTION!

The "warnings for the use of liquid nitrogen" must be strictly observed when filling the Dewar vessel (see chapter 2, Safety precautions).

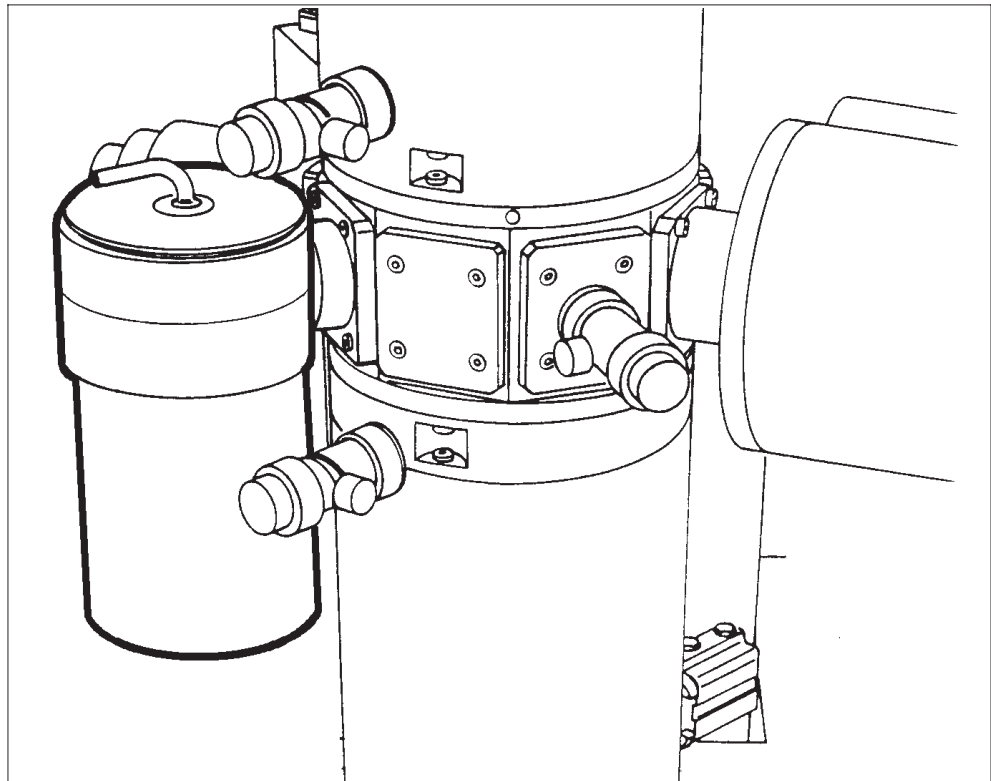


Fig. 1-29: Anticontaminator

1.2.5

Goniometer

The goniometer (Fig. 1-30) integrated in the LEO 912 OMEGA is of the *eucentric side entry* type with the following base components:

- Specimen stage with specimen shift
- Specimen tilt and
- Specimen holder

Four axes of the standard equipment are motorized for specimen manipulation:

- X-axis
- Y-axis
- Z-axis (height adjustment to position the specimen to the eucentric axis and for coarse focusing)
- Θ axis for specimen tilt about the eucentric axis

Optional specimen rods allow rotation or tilt of the specimen in an additional axis besides the aforementioned.

Two specimens can be loaded in the standard rod and one each brought in the beam path with the specimen changer. Special rods with specimen holders made of graphite or beryllium (see chapter 2, Safety precautions) reduce the background signals in EDX analysis. The goniometer is controlled by an independently operating microprocessor, and operated by keys from the control panel. Precision shift in X and Y is done by a trackball.

Specimen positions for all axes can be stored and recalled by the GONIOMETER menu of the operating program. The program option *meander scan* is available for the program-controlled screening of specimens.

Fig. 1-31 on the following page is a sectional view of goniometer and column.

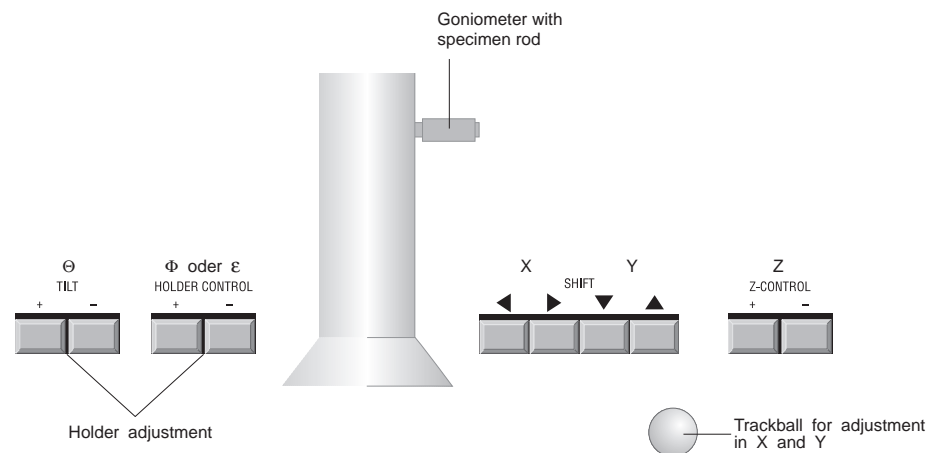


Fig. 1-30: Goniometer

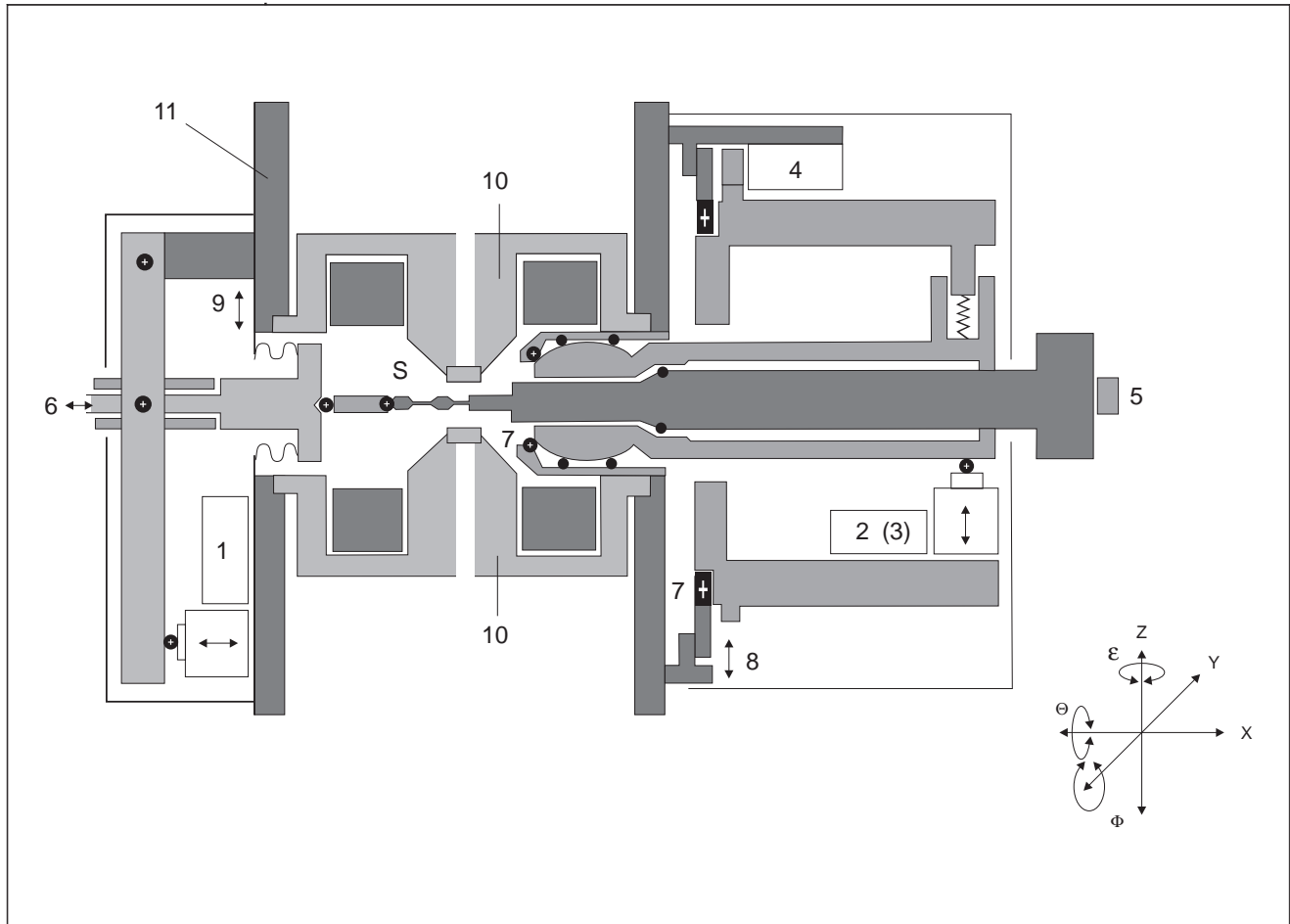


Fig. 1-31: Sectional view of electron-optical column and goniometer

- | | |
|----|--|
| S | Specimen position (2 specimens) |
| 1 | Motor drive for X shift |
| 2 | Motor drive for Z shift |
| 3 | Motor drive for Y shift (not visible) |
| 4 | Motor drive for eucentric tilt Θ |
| 5 | Motor drive for optional rod (2nd tilt axis Φ or specimen rotation ϵ) |
| 6 | Specimen changer for 2nd specimen position |
| 7 | Bearing for eucentric tilt |
| 8 | Mechanical (factory) alignment of eucentric axis |
| 9 | Mechanical (factory) alignment of counterbearing |
| 10 | Objective lens |
| 11 | Column |

1.2.6 Viewing binoculars

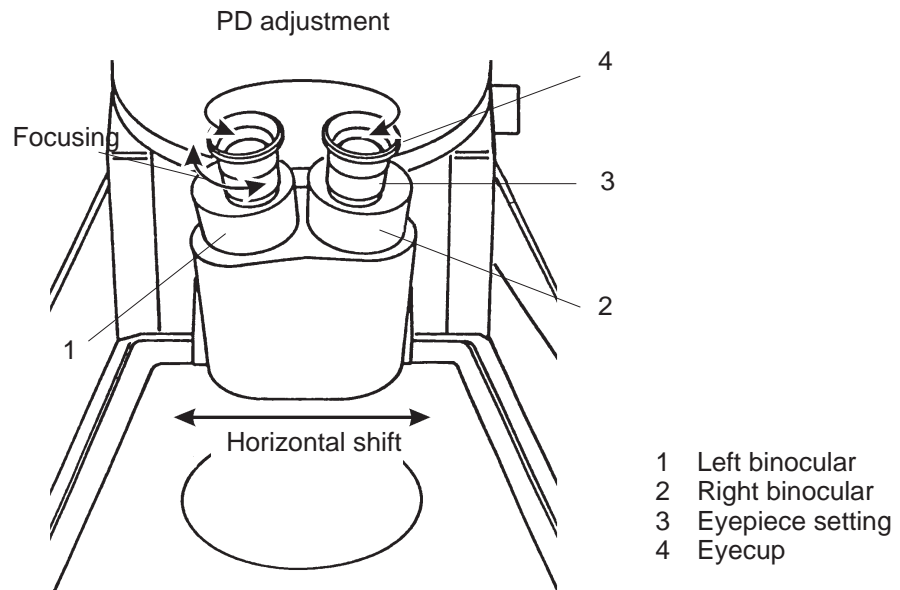


Fig. 1-32: Viewing binoculars

The image on the focusing fluorescent screen is observed through the viewing binoculars which magnifies the image 9x. The binoculars can be pushed back for observation of the large fluorescent screen and moved horizontally over the length of the focusing fluorescent screen. This horizontal movement is recommended for focusing at high magnification if the specimen is already oriented to the photographic format and there is no suitable spot for focusing around the index point.

The PD is adjusted by turning the two binocular tubes in or out.

Both eyepieces are separately focusable. Focusing is best made using the index point. The eyepieces are equally well suited for eyeglass wearers because of the high position of the exit pupil. Eyeglass wearers must fold down the rubber eyecups.

1.2.7

Fluorescent screens

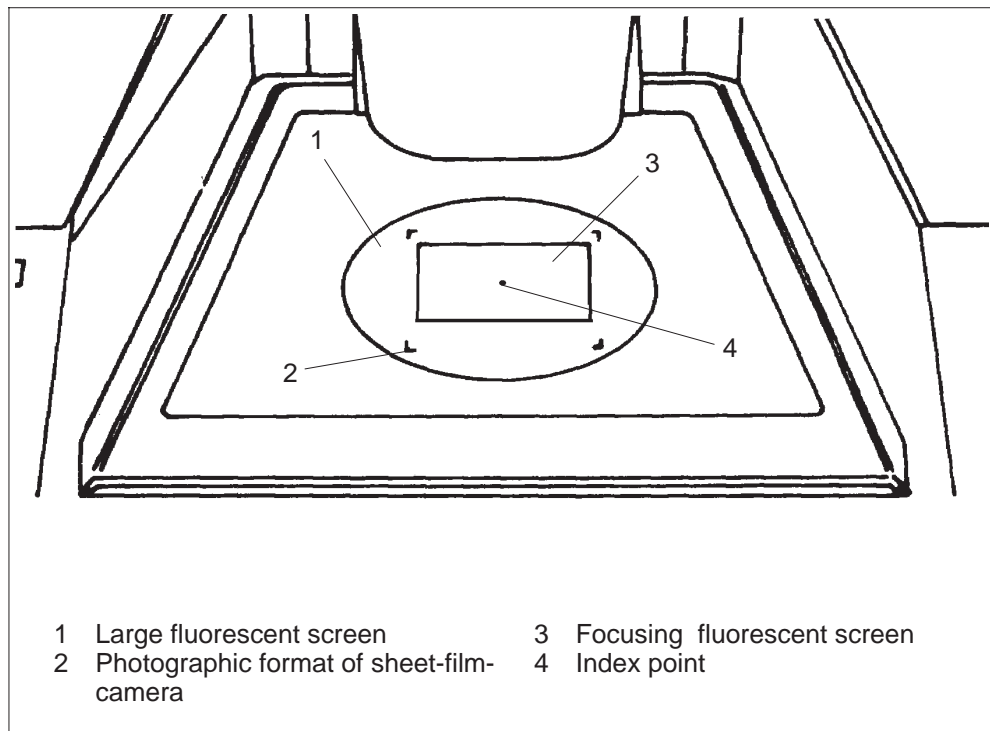


Fig. 1-33: Fluorescent screens

Both fluorescent screens are pneumatically operated, and can be swung in or out separately or jointly. They are controlled by keys on the left operating panel.

1.2.8 Sheet-film camera

The sheet-film camera, with a microprocessor of its own, is most convenient for inside-the-vacuum large-format photography. Fig. 1-34 on the following page is a schematic sectional view of the instrument.

Sheet-film holders for 3 1/4 x 4" sheet film are generally used. Special plate holders are available for glass plates, and a special holder for 6.5x9 cm sheet film or glass plates. The sheet-film magazine has a capacity of 40 exposures, for plate holders and special holders the capacity is 20.

Exposure measurement is made by two systems which measure the electron current over surfaces of different size.

The fully automatic operation of the camera includes exposure measurement, shutter control, imprint of various instrument data, film advance and the lifting of the fluorescent screen.

A great number of specific adjustments and options are possible by the camera menu:

- Sheet-film or 35mm camera
- Manual or automatic exposure time preselection
- Exposure measuring system
- Density adjustment (2 possible adjustments)
- Single or multiple exposure

The sheet-film camera also offers the option *exposure series*.

- Position series, e.g. for photomontage
- Tilt series for electron-microscopic tomography
- Density series for optimization of exposures, and
- Focus series with preselectable defocusing steps, automatic or interactive.

The instrument data will be imprinted on the negative, output to a printer (option) and stored in an ASCII file on the hard disk. This allows for additional comments; an extended data record is then used.

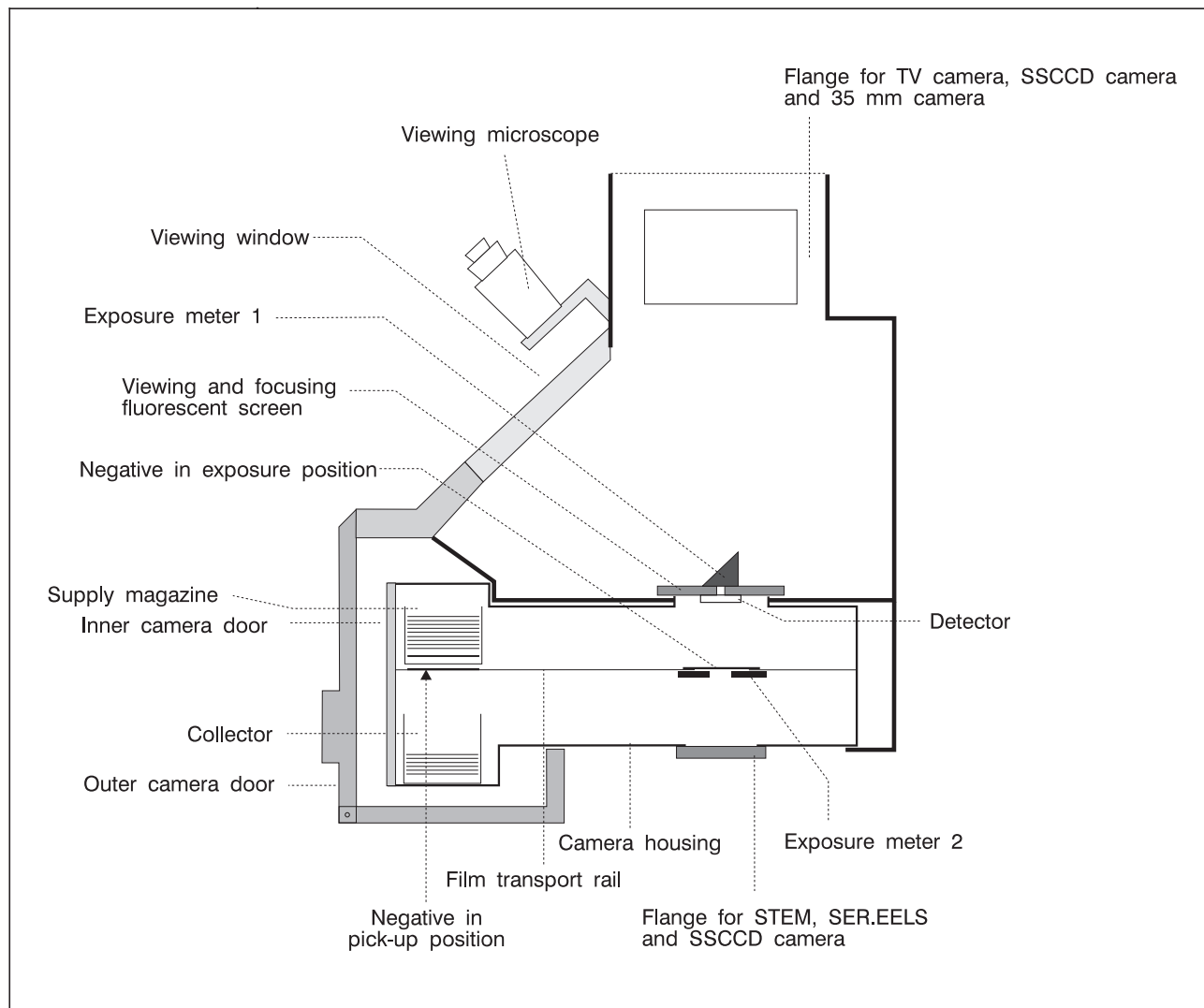
Explanation of instrument data on the negative

in imaging mode:

Code	Film number	Date	Magnification	μm marker
RB	999999	220292	M 20000	<0.72>
Test Bild xx		U 100	250	+ 45.0°
16 characters text		HV	Energy loss ΔE	Tilt angle or defocusing or current of exposure- meter 2

in diffraction mode:

Code	Film number	Date	Camera length
RB	999999	220292	D 290 mm
Test Bild xx		U 100	0 + 45.0°
16 characters text		HV	Energy loss ΔE
			Tilt angle or defocusing or current of exposure- meter 2



Version 3.20

Fig. 1-34: Sheet-film camera

1.2.9**High-voltage unit**

The high-voltage unit (Fig. 1-35) generates the voltage for electron acceleration. It is contained in a separate cabinet which is connected with the instrument by the high-voltage cable. The high voltage is controlled by a separate microprocessor; controlled through the GUN menu. The high voltage is variable from 60kV to 120kV in 20kV steps. High-voltage adjustment in 10V steps is optional.

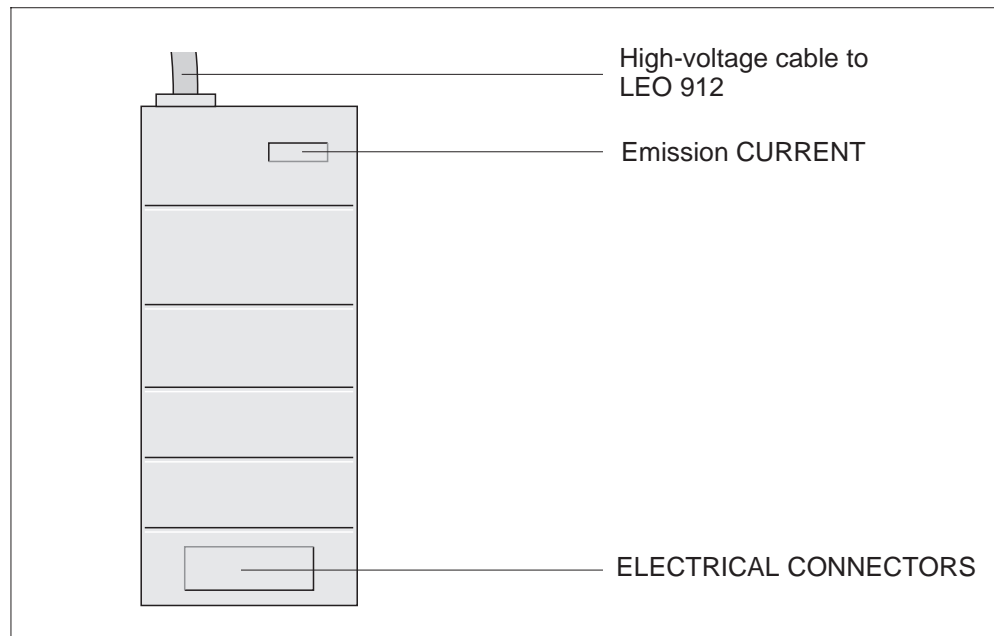


Fig. 1-35: High-voltage unit

1.2.10

Memory/data management

Data stored in the RAM (Random Access Memory) are divided into three categories:

- System data
 - Filament data
 - AIS data
 - User data
 - Calibration data
- EM912 program
- Actual data
 - mode-dependent settings by keys
 - Softkeys
 - Encoders
 - Keyboard
 - e.g. magnification, brightness, etc.

The data are stored in fixed sequences upon EM switch-on, when quitting the program or using the EM (User Data). RAM, hard disk and floppy disks are available as storage media (see Fig. 1-36).

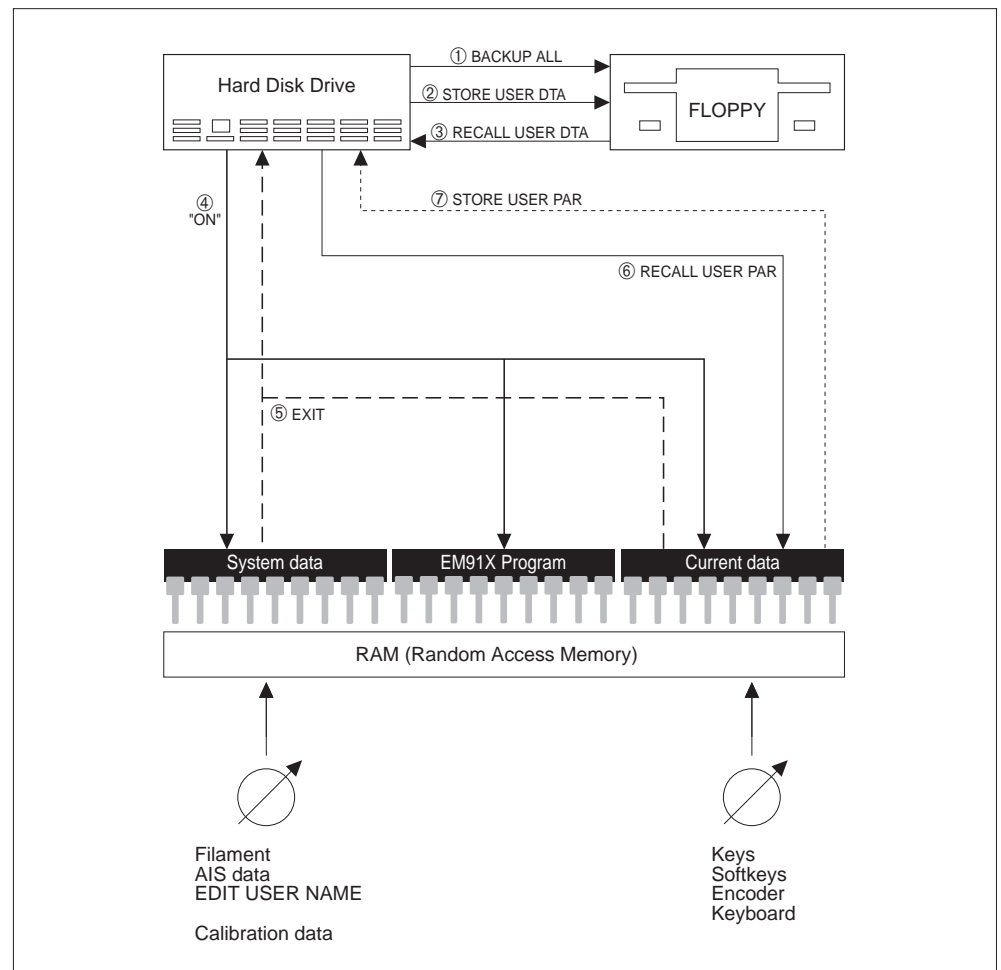


Fig. 1-36: Memory/data management

The memory is managed dependent on the executed operating steps as described below:

- ① **BACKUP ALL**
All EM data on the hard disk are copied on a floppy disk in the disk drive.
- ② **STORE USER.DTA:**
The four free lens programs and the last used User Data are copied from the hard disk on a floppy disk. The user names are not stored here, because they belong to the system files (see ⑤).
- ③ **RECALL USER.DTA:**
The four free lens programs and the last stored User Data record are copied from a disk to the hard disk, but not activated. The user names are not re-stored here, because they belong to the system files (see ④).
- ④ **Key switch = ON**
Operating system, EM program, system data and the last activated lens program are loaded from the hard disk into the RAM. The so-called USER 0 is instantly active, the EM is ready for operation with data set as before switch-off.
- ⑤ **EXIT**
Upon EM switch-off the system files and all actual RAM data are stored on hard disk (USER 0). These files are re-activated upon switch-on. (see ④).
- ⑥ **RECALL USER PAR**
The data of the selected user no. x are loaded from the hard disk into the RAM and activated. Only this function activates user data. The name is part of the system files, which means that it is not changed here.
- ⑦ **STORE USER PAR. OVERWRITE MEMORY?**
The actual EM data are copied from the RAM on the hard disk under user no. x. The name is not part of the files.

Listing separate data memories

Separate data memories are created for different instrument settings, for easy operation and quick change between different imaging modes. The control software of the LEO 912 OMEGA automatically takes over all important storage processes of:

HV steps	Objective lens calibration values for MAG and LOW MAG C3 values for TEM and SPOT illumination AIS data records complete lens program
SPOT mode	Spot diameter (illuminating aperture) ILL. stigmator values AIS control
TEM mode	Illuminating aperture Image shift values ILL. shift values ILL.stigmator values Magnification

LOWMAG	Illuminating aperture Image shift values ILL. shift values ILL. stigmator values TEM stigmator values Magnification
Diffraction	Image shift Diff. stigmator values Camera length
Spectrum	Image Shift
Darkfield	Ill. tilt (5 memory values)
MDF	Ill. shift Image shift
DSA	AIS control Spot mode and spot size Image shift

In addition, the user can define, store and call various data.

For this purpose, there are eight different, name-editable data memories available in the USER menu.

Data storage in a USER file

The following data are stored in a user-specific instrument setting to a USER key.

Encoder Image (left control panel) ¹⁾

Image_Stig_M_X
 Image_Stig_M_Y
 Image_Stig_LM_X
 Image_Stig_LM_Y
 Image_Shift_M_X
 Image_Shift_M_Y
 Image_Shift_LM_X
 Image_Shift_LM_Y
 Diffr_Stig_M_X
 Diffr_Stig_M_Y
 Diffr_Stig_LM_X
 Diffr_Stig_LM_Y
 Spec_Shift_M_X
 Spec_Shift_M_Y
 Diffr_Shift_M_X
 Diffr_Shift_M_Y
 Diffr_Shift_LM_X
 Diffr_Shift_LM_Y

Encoder GUN (right control panel)

Filament_Current
 Emission_Current

Encoder Illumination (right control panel) ¹⁾

Illumination_Tem_Stig_M_X
 Illumination_Tem_Stig_M_Y
 Illumination_Tem_Stig_LM_X
 Illumination_Tem_Stig_LM_Y
 Illumination_Spot_Stig_M_X
 Illumination_Spot_Stig_M_Y
 Illumination_Spot_Stig_LM_X
 Illumination_Spot_Stig_LM_Y
 Illumination_Tilt_M_X
 Illumination_Tilt_M_Y
 Illumination_Tilt_LM_X
 Illumination_Tilt_LM_Y
 Illumination_Shift_M_X
 Illumination_Shift_M_Y
 Illumination_Shift_LM_X
 Illumination_Shift_LM_Y

Encoder Objective (right control panel) ¹⁾

Focus_Coarse
 Focus_Fine
 P1_Fine_M_Diffr
 P1_Fine_LM_Image
 Obj_Fine_LM_Diffr

Encoder Brightness (right control panel) ¹⁾

Focus_C3_MAG_SPOT
 Focus_C3_LM_SPOT
 Focus_C3_TEM_FINE
 Focus_C3_Wobble_Amplitude

Operating modes

Mag mode (MAG, LM)
 Image mode (IMAGE, DIFFR)
 Image encoder mode (Stig, Shift)
 Illumination encoder mode (Tilt, Shift, Stig)
 Brightness encoder mode (TEM, SPOT)
 Brightfield mode (ON, OFF)
 AIS_Mode (ON, OFF)
 Focus switch (COARSE, FINE)
 Focus mode (SCHERZER, MAG-DEP, FIX)
 Focus type (CONTINUOUS, COARSE-FINE)
 Defocus_mode (SCHERZER, MAG-DEP, FIX)
 Defocus_mode_Mag_Dependent (LOW, MED, HIGH)
 Defocus_switch (ON, OFF)
 MDF mode (ON, OFF)
 MDF direction (PARALLEL, FREE)
 Cone illumination mode (ON, OFF)

Sheet-film camera

User code
 Free input
 Comment
 Film Dens A
 Film Dens B
 Data Dens A
 Data Dens B
 Exposure number
 Exposure meter (SMALL, SCREEN, CAMERA COLL.)
 Exposure mode (FIX, AUTO)
 Fix time

Option 35mm camera

Film Dens
 Data Dens
 Fix time

Option exposure series

Focus_number
 Focus_start
 Focus_step
 Time_number
 Time_start
 Time_step
 Tilt_number
 Tilt_start
 Tilt_step
 δE number
 δE start
 δE step

Other values

M_Pointer_Image (Magnification MAG MODE)
 M_Pointer_Diffr (Camera length MAG MODE)
 LM_Pointer_Image (Magnification LM MODE)
 LM_Pointer_Diffr (Camera length LM MODE)
 M_Spot_Pointer_TEM (Ill.angle MAG MODE)
 M_Spot_Pointer_Spot (Spot size MAG MODE)
 LM_Spot_Pointer_TEM (Ill.angle LM MODE)
 LM_Spot_Pointer_Spot (Spot size LM MODE)
 HT_Pointer (high-voltage step)
 Lens_Program_Pointer (selected lens program)
 DF_Values_Pointer (darkfield offset 1 ... 5)
 MIS_Select (selected AIS condenser aperture)
 Focus_Step_Fix
 Focus_Step_Mag_Dep
 Defocus_Value_Fix
 Defocus_Step_Mag_Dep
 Defocus_Value_Scherzer
 Focus_Wobble_Amplitude
 Focus_Aid_Value

Option DSA**Encoder Image** (left control panel)

Diffr_Shift_DSA_BF_M_X
Diffr_Shift_DSA_BF_M_Y
Diffr_Shift_DSA_BF_LM_X
Diffr_Shift_DSA_BF_LM_Y
Diffr_Shift_DSA_DF_M_X
Diffr_Shift_DSA_DF_M_Y
Diffr_Shift_DSA_DF_LM_X
Diffr_Shift_DSA_DF_LM_Y

Encoder Illumination (right control panel)

DSA_ILL_Tilt_M_X
DSA_ILL_Tilt_M_Y
DSA_ILL_Tilt_LM_X
DSA_ILL_Tilt_LM_Y
DSA_ILL_Shift_M_X
DSA_ILL_Shift_M_Y
DSA_ILL_Shift_LM_X
DSA_ILL_Shift_LM_Y

Encoder Brightness (right control panel)

Focus_C3_DSA_Spot

Other values

LM_BF_DSA_Pointer
LM_DF_DSA_Pointer
Mag_BF_DSA_Pointer
Mag_DF_DSA_Pointer

Option MDF

MDF_Offset_X_Scan
MDF_Offset_Y_Scan
MDF_Offset_X_Descan
MDF_Offset_Y_Descan
MDF_Offset_X_Tilt
MDF_Offset_Y_Tilt
MDF_Descan_CORR_X
MDF_Descan_CORR_Y

Darkfield

DF_Offset_X_1
DF_Offset_Y_1
DF_Offset_X_2
DF_Offset_Y_2
DF_Offset_X_3
DF_Offset_Y_3
DF_Offset_X_4
DF_Offset_Y_4
DF_Offset_X_5
DF_Offset_Y_5

Spectrometer

ZL Fine Image
ZL Fine Spectrum
HW Fine Image
 ΔE
 ΔE Start
 ΔE Stop
 ΔE Step
 ΔE Delay
Filter Mode (Spectrum/Image)
Filter function

Electron detector (option)

Electron Detector Voltage
Electron Detector Mode (Cage/PMT)
Electron Detector Time

- 1) A calibration value is stored in a separate file for all values marked with ¹⁾, and the actual USER values are set to the calibration values by the CALIBRATE functions.

1.2.11**Extensions**

All presently known imaging and analysis methods have been considered for the design of the LEO 912 OMEGA, especially those of the objective lens. The instrument is easily upgradable to a universal analytical TEM. The most important extensions include:

- Specimen holders for different applications
- TV cameras for different applications
- DSA Digital Scanning Attachment with detectors for brightfield/darkfield imaging, secondary electrons, backscattered electrons
- X-ray microanalysis systems of different make *
- Image analysis systems of different make *

The LEO 912 OMEGA is provided with various optional interfaces for remote control of all relevant functions.

For details ask your LEO specialist.

**SPECIAL NOTE:**

Sufficient space should be provided in the installation room for all attachments marked with an asterisk *.

1.3 Operating controls - Control panels

Fig. 1-37 shows the control panels of the LEO 912 OMEGA. There is one panel each to the right and left of the column, with the operating controls for the electron-optical parameters.

The keys and the trackball for the goniometer control are provided on the table top on both sides of the column.

Operating parameters are input and changed from the keyboard built into the table top. The operating controls for the vacuum system and the floppy disk drive are at the outside of the control panel.

The operating controls are described in detail on the following pages.

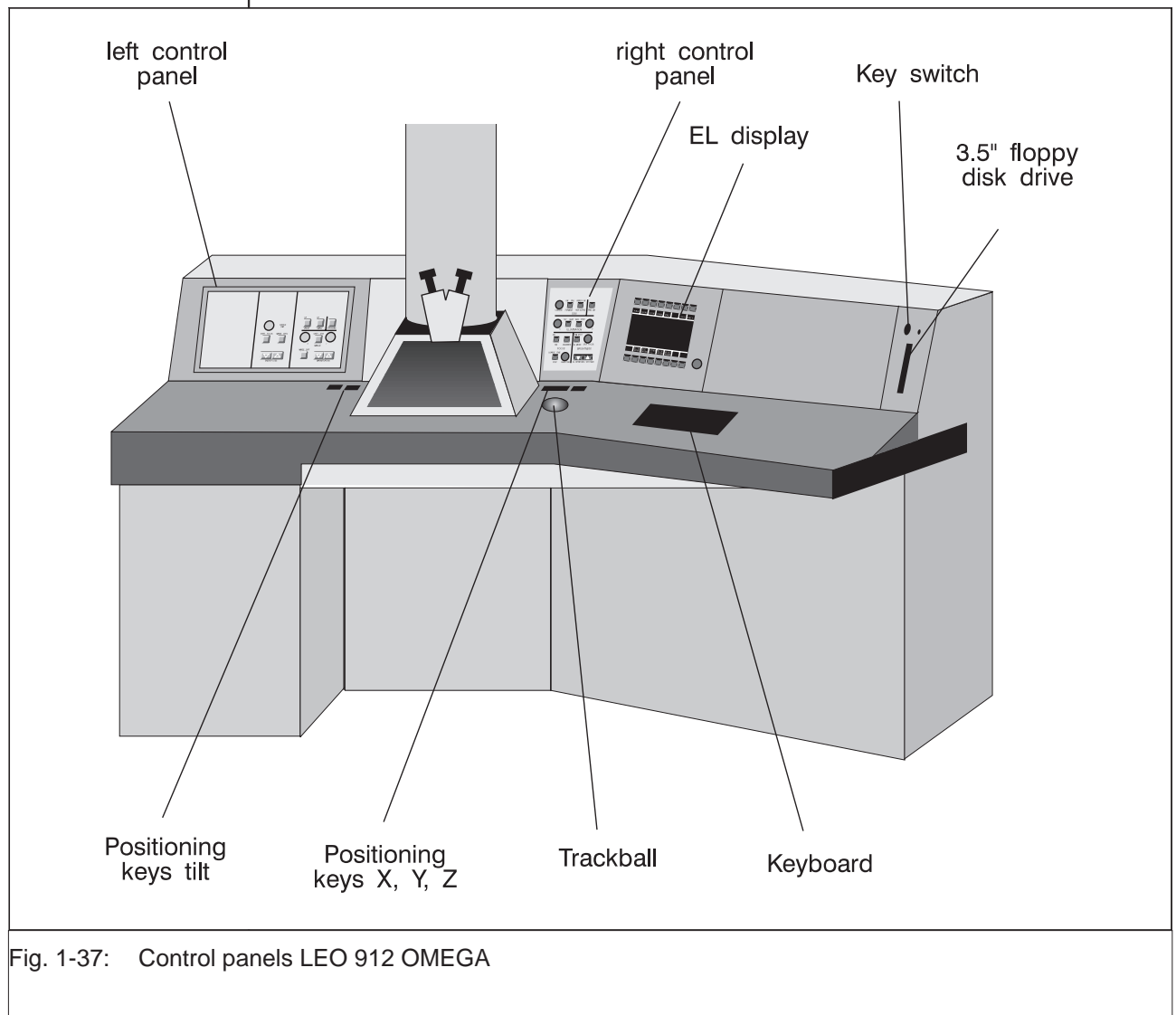


Fig. 1-37: Control panels LEO 912 OMEGA

1.3.1 Operating controls - General

Key switch

starts the LEO 912 OMEGA.

3 positions:

1st position:

- IGP overnight service

2nd position:

- Vacuum system started (rotary pump + TMP)

3rd position:

- Host computer activated
- EM operating system started
- EM initialized
- Lenses activated

3.5" floppy disk drive (1.44MB)

To copy files between the EM-integrated hard disk and floppy disk in either direction.

RESET (sunken)

Restart of host computer independent of the other instrument components (activated with a blunt item of approx. 3mm dia., e.g. a match)

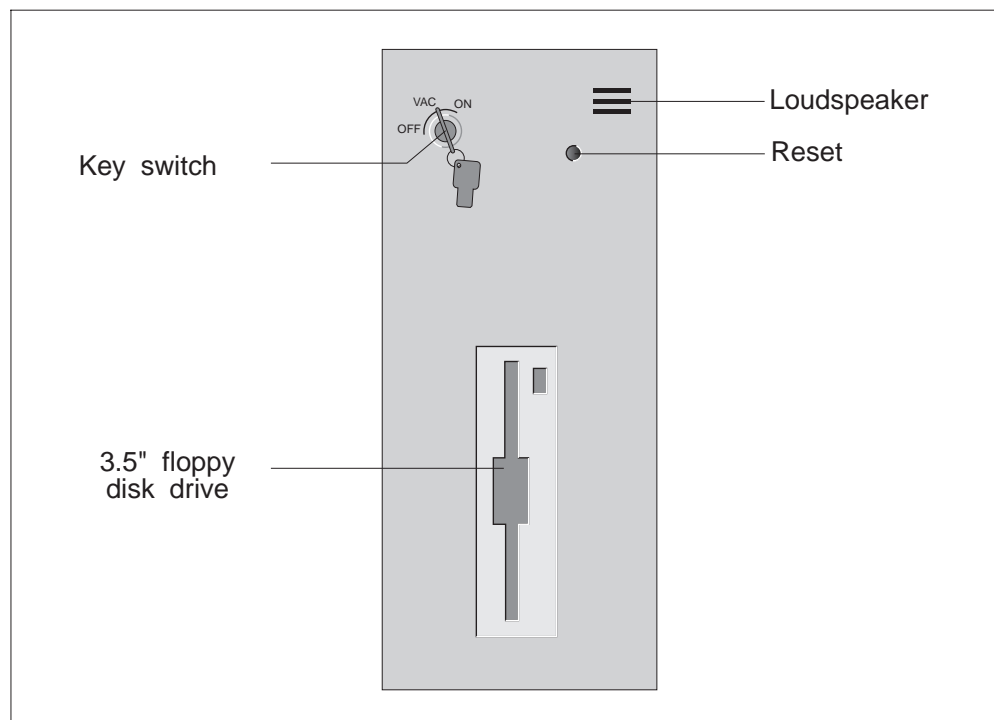


Fig. 1-38: Operating controls, general

1.3.2

Operating controls - Goniometer positioning

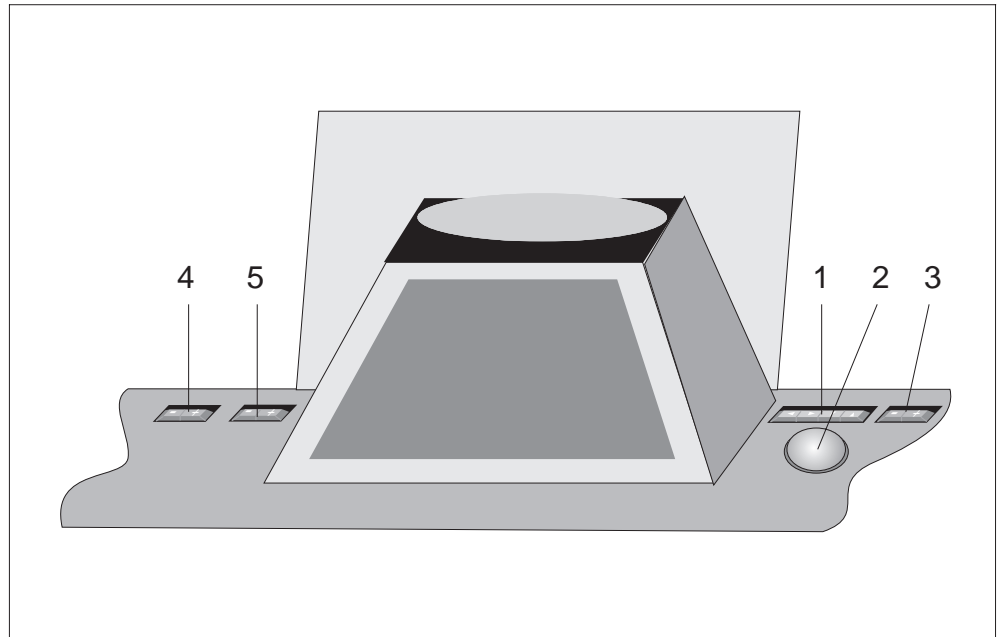
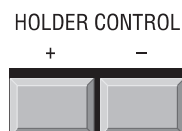
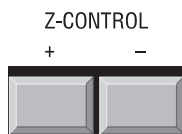
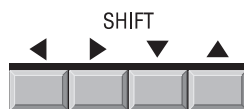


Fig. 1-39: Operating controls for goniometer positioning

**1 Arrow key SHIFT**

Specimen shift in the directions X and Y indicated by the arrows

2 Trackball or dynamic joystick

Horizontal precision shift of the specimen in any direction (x, y)

3 Key Z CONTROL, - and +

Vertical adjustment of specimen

4 Key TILT, - and +

Specimen tilt (Θ)

5 Key HOLDER CONTROL, - and +

Adjustment of the additional function integrated in the specimen holder (option dual tilt or rotation Φ , ϵ)

1.3.3

Left control panel

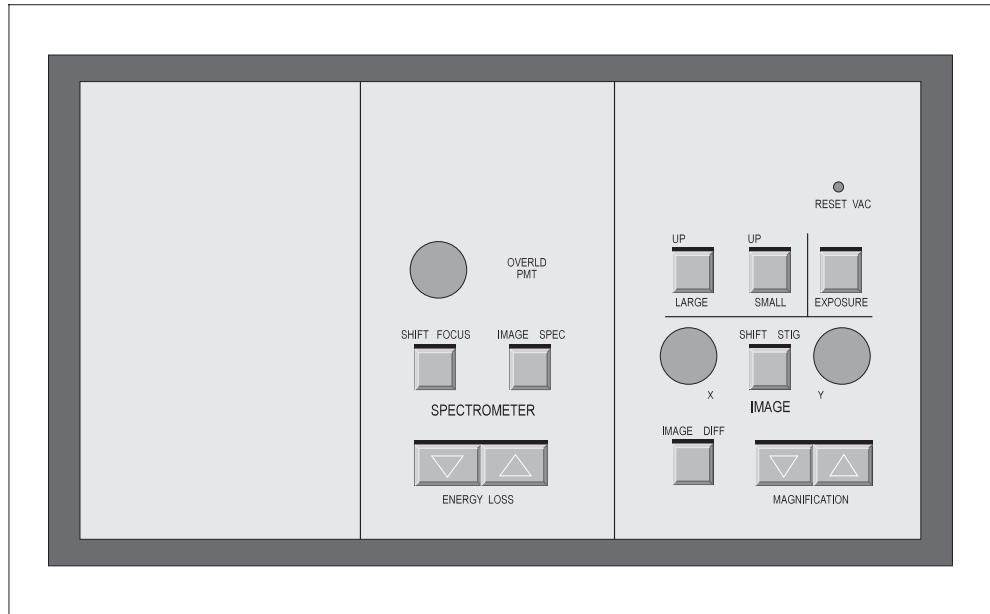
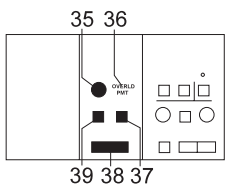
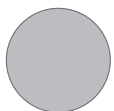


Fig. 1-40: Left control panel



SPECTROMETER control field

with the operating controls for the spectrometer.



35 Knob

for spectrometer calibration. Spectrometer fine adjustment for zero balancing or focusing of projector lens P4 together with SHIFT/FOCUS switch key (39).



SPECIAL NOTE:

The spectrometer calibration value is automatically adjusted with instrument switch-on, which means that the spectrometer does not normally need to be calibrated.

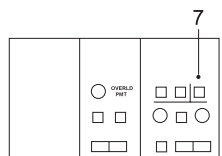
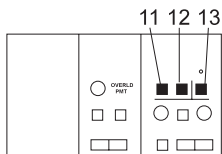
**OVERLD
PMT**

IMAGE SPEC



ENERGY LOSS

SHIFT FOCUS



UP



LARGE

UP



SMALL

36 OVERLD PMT display

Signal lamp OVERLD PMT on displays photomultiplier overload.

37 IMAGE/SPEC switch key


to change between final image types


- Yellow signal lamp IMAGE on:
The object image is displayed as final image.
- Red signal lamp SPEC on:
The spectrum is imaged as final image.

Selection of image type by changing the focal length of projector lens P4.

38 ENERGY LOSS double key

Setting the electron energy selected for imaging (compensation of energy loss in spectrometer).

Key  increases the electron energy

Key  reduces the electron energy

39 SHIFT/FOCUS switch key

selects the calibration value (spectrometer balancing)

- Yellow signal lamp SHIFT on:
Spectrometer zero balancing is made with knob (35).
- Red signal lamp FOCUS on:
Fine adjustment of P4 focusing to the achromatic image plane with knob (35).

SCREEN LIFT control field**7 RESET VAC (sunken)**

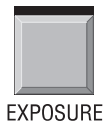
Restart of vacuum system independent of host computer (activated by blunt item of approx. 3mm dia., e.g. a match)

11 Key LARGE

lifts large and small fluorescent screens and/or lowers large fluorescent screen
Red signal lamp UP is on: large fluorescent screen is fully raised.

12 Key SMALL

lifts small fluorescent screen and/or lowers large and small fluorescent screens
Red signal lamp UP is on: small or large fluorescent screen fully raised.



EXPOSURE

13 Key EXPOSURE

Start of single exposure selected by the CAM menu, LED in key lights continuously for recognition in dimmed room.
This function includes lifting and/or lowering of the fluorescent screens.

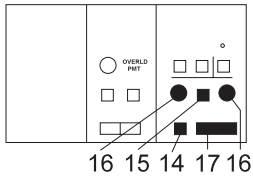


IMAGE control field

combines the operating controls to adjust the imaging parameters

IMAGE DIFF



14 Switch key IMAGE / DIFF

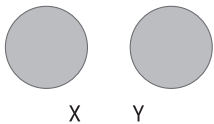
Selection of imaging mode
Yellow signal lamp IMAGE is on: imaging mode *brightfield* / *darkfield* on
Red signal lamp DIFF is on: imaging mode *diffraction* on

SHIFT STIG



15 Switch key SHIFT / STIG

Selection of image correction (separate data files for IMAGE and DIFF)
Yellow signal lamp SHIFT is on:
image shift on (IMAGE) or *diffraction image shift* on (DIFF)
Red signal lamp STIG is on:
imaging stigmator on (IMAGE) or *P1 stigmator* on (DIFF)





16 Control knobs X and Y

Adjustment of X and Y values for image shift and/or imaging stigmator



MAGNIFICATION

17 Double key MAGNIFICATION

Magnification adjustment
Key  increases the adjusted magnification by approx. 25 %
Key  reduces it by approx. 25 %

1.3.4 Right control panel

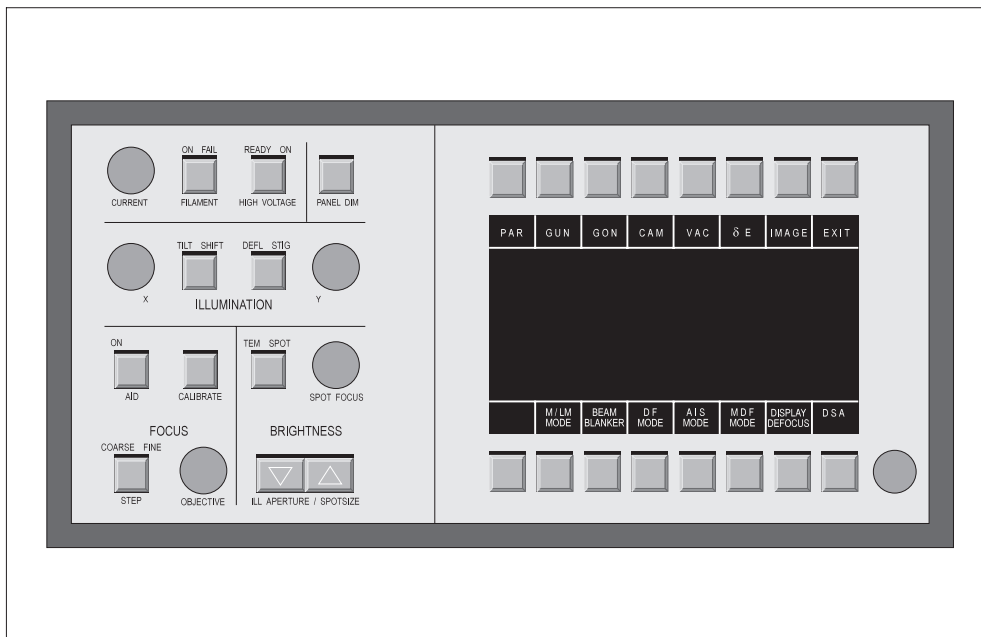


Fig. 1-41: Right control panel

GUN control field

18 Encoder CURRENT

Dual function:

- Adjustment of emission current
- Adjustment of filament heating current (only with called GUN menu and function key FILAMENT CURRENT activated by this menu)

19 Key FILAMENT

Filament current switched on or off

Red signal lamp ON is on: filament current on

Yellow signal lamp FAIL is on: no filament current (e.g. filament burnt out)

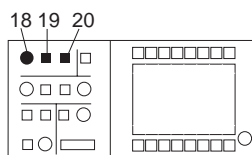
20 Key HIGH VOLTAGE

Accelerating voltage switched on or off.

Green signal lamp READY is on: high-voltage go-ahead

Red signal lamp ON is on: accelerating voltage switched on

Version 3.20



CURRENT

ON FAIL

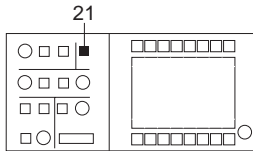


FILAMENT

READY ON



HIGH VOLTAGE

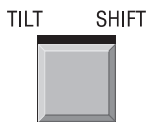
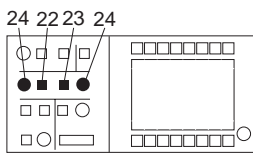


Panel illumination control field

21 Key PANEL DIM

To select the brightness of the panel illumination

Key depressed: brightness drops to minimum and increases again to maximum.



ILLUMINATION control field

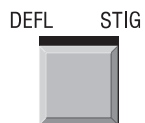
combines the operating controls for illumination parameter adjustment.

22 Switch key TILT / SHIFT

Selection of illumination adjustment

Yellow signal lamp TILT is on: beam tilt on

Red signal lamp SHIFT is on: beam shift on

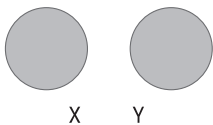


23 Switch key DEFL / STIG

Selection of illumination correction

Yellow signal lamp DEFL is on: illumination deflection on

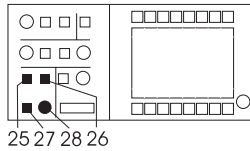
Red signal lamp STIG is on: illumination stigmator on



24 Encoders X and Y

Multiple function:

- Adjustment of X and Y values for beam tilt, beam shift and illumination stigmator (operating mode displayed by signal lamps)
- Adjustment of further parameters by the menus GUN, AIS-ADJUST and DARKFIELD (see table at the end of this chapter). The signal lamps are turned off.



ON



AID



CALIBRATE

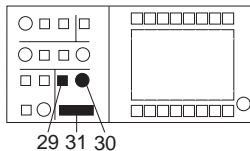
COARSE FINE



STEP



OBJECTIVE



TEM SPOT



ILL MODE



SPOT FOCUS



ILL APERTURE / SPOT SIZE

FOCUS control field

25 Key AID

Focusing aid (wobbler)

Red signal lamp ON is on: focusing aid on

26 Key CALIBRATE

focuses objective lens to eucentric axis

27 Key STEP

Change of step width for objective lens focusing

Yellow signal lamp COARSE is on: step width, coarse (only MAG IMAGE mode)

Red signal lamp FINE is on: step width, fine (step width definition by menu FOCUS PARAM).

28 Encoder OBJECTIVE

Multiple function:

- Objective lens focusing (focusing of produced image)
- P1 focusing for LOW MAG and diffraction
- Adjustment of focusing step width by menu FOCUS PARAMETERS
- Adjustment of objective lens wobbler amplitude by menu FOCUS PARAMETERS

BRIGHTNESS control field

29 Switch key ILL. MODE

Selection of illumination mode

Yellow signal lamp TEM on: normal state *widefield illumination* on

Red signal lamp SPOT on: *spot illumination* on

30 Encoder SPOT FOCUS

Multiple function:

- Condenser focusing
- Adjustment of further parameters by the menus

FREE MAG. ADJUST and FREE COND. ADJUST (see table at the end of this chapter)

31 Double key ILL. APERTURE / SPOT SIZE

Adjustment of

- Brightness in TEM illumination mode
- Spot diameter in SPOT illumination mode

1.3.5 Operating controls - monitor

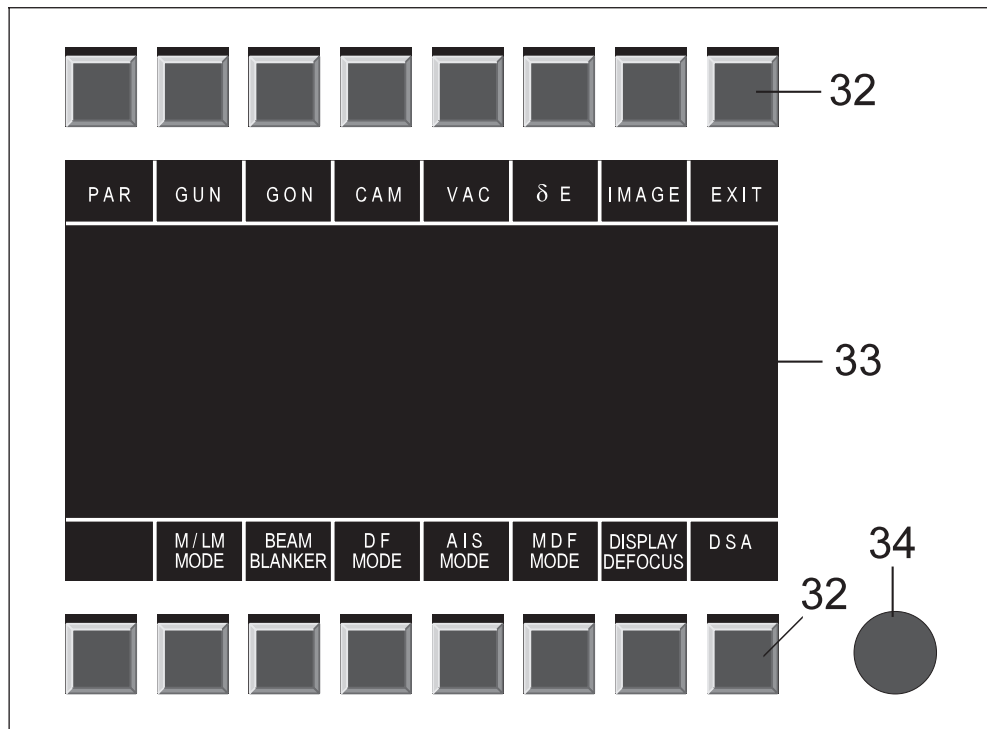


Fig. 1-42: Operating controls - monitor

32 Function keys

Eight keys each above and below the monitor with variable functions depending on the called menu. The actual functions of the keys are displayed by text fields in the top and bottom part of the monitor (33). Each of the 16 keys is assigned to the text field on top and at the bottom of the monitor.

33 Control monitor

Features:

- Type: electro-luminescence display (ELD)

Functions:

- Operator guidance by menu
- Output unit for data and messages from the LEO 912 OMEGA
- HELP text monitor
- Screen protection: the function is always active and switches off the EL display if the instrument is not operated for 5 minutes. It is re-activated by pushing any key on control panel or keyboard.

34 Potentiometer

regulating the brightness of the monitor

Keyboard

(standard PC keyboard)

Function:

Input unit for data and commands to the LEO 912 OMEGA

Supplementary function encoders on right operating panel

Encoder	Function	Menu	Softkey in menu
CURRENT (Control field GUN)	Adjustment heating current filament	GUN	FILAMENT CURRENT
X and Y (Control field ILLUMINATION)	Symmetrization emission image filament	GUN	FILAMENT PRECENTERING
	Adjustment of beam alignment	GUN	BEAM ALIGNMENT
	Adjustment AIS offset for beam deflection	AIS ADJUST	ADJUST AIS UPPER
	Adjustment AIS offset for HR beam deflection	AIS ADJUST	ADJUST HR UPPER
	Adjustment AIS offset for beam redeflection	AIS ADJUST	ADJUST AIS LOWER
	Adjustment AIS offset for correction condenser astigmatism	AIS ADJUST	ADJUST STIG COR.
	Adjustment AIS offset for correction of irradiation direction	AIS ADJUST	ADJUST TILT COR.
	Adjustment darkfield offset	DARKFIELD	ADJUST DF OFFSET
	Adjustment MDF Offset	MDF	ADJUST MDF OFFSET

Supplementary function encoders on right operating panel, continued on next page

Supplementary functions, contd.

Encoder	Function	Menu	Softkey in menu
OBJECTIVE (Control field FOCUS)	Adjustment focusing step width	FOCUS PARAMETER	SELECT FOC. STEP
	Adjustment defocus value	FOCUS PARAMETER	SELECT DEFOCUS
	Adjustment of objective lens wobbler amplitude	FOCUS PARAMETER	ADJUST WOB. AMPL.
SPOT FOCUS (Control field BRIGHTNESS) only with installed option FREE LENS CONTROL	Adjustment lens current 1st projector lens	FREE MAGNIFICATION	ADJUST P1
	Adjustment lens current 2nd projector lens	FREE MAGNIFICATION	ADJUST P2
	Adjustment lens current 3rd projector lens	FREE MAGNIFICATION	ADJUST P3
	Adjustment lens current 4th projector lens	FREE MAGNIFICATION	ADJUST P4
	Adjustment objective lens current for LM mode	FREE MAGNIFICATION	ADJUST OBJ. LM
	Adjustment lens current 1st condenser	FREE CONDENSER	ADJUST C1
	Adjustment lens current 2nd condenser	FREE CONDENSER	ADJUST C2
	Adjustment lens current 3rd condenser	FREE CONDENSER	ADJUST C3

1.4 Operating controls - Electron-optical column

1.4.1 Design of electron-optical column

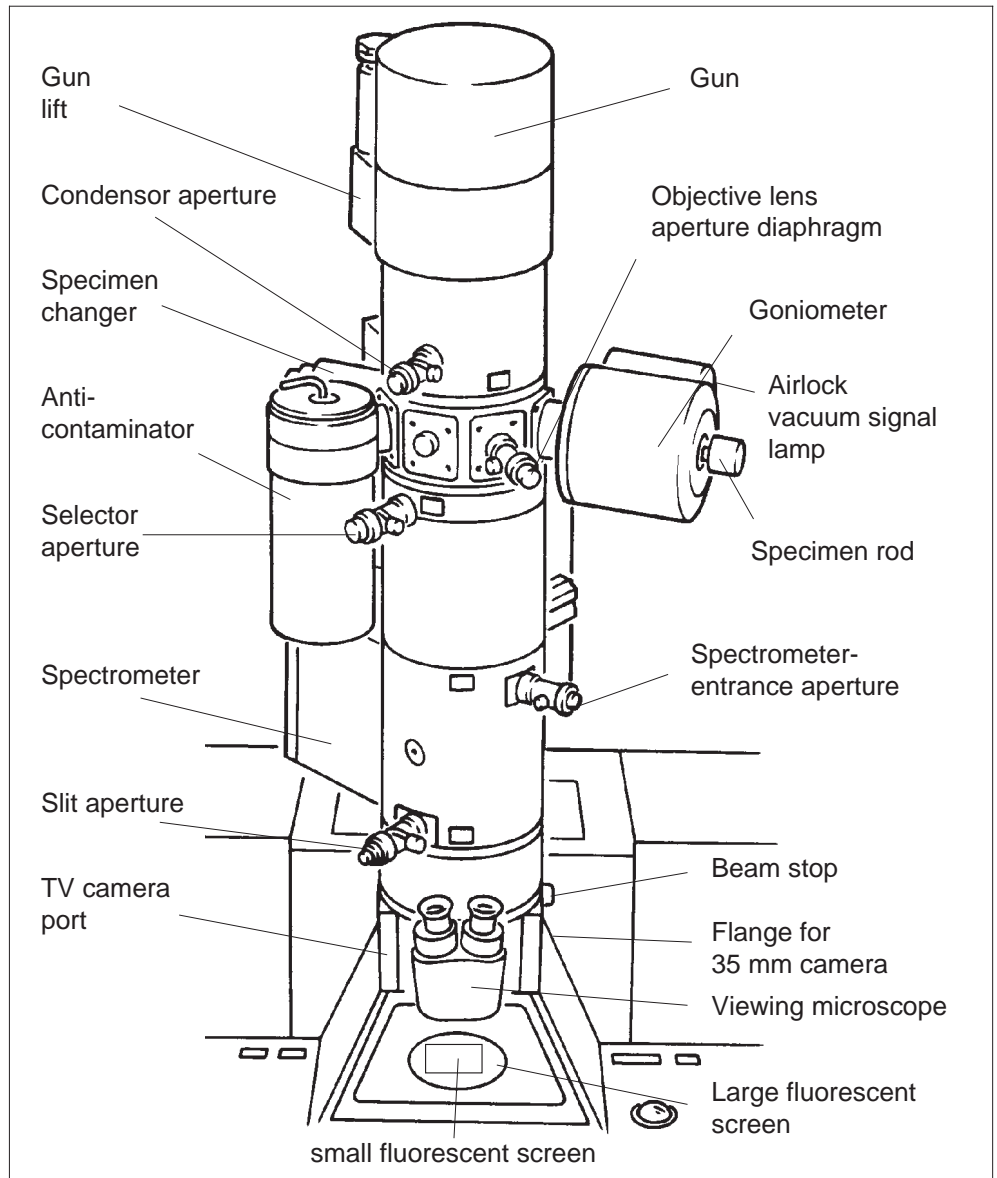


Fig. 1-43: Electron-optical column

Condenser aperture

(Luminous field aperture)

Aperture holder:

Position 1: 400 μm

Position 2: Multi-hole aperture

2a 150 μm aperture

2b 37 μm aperture (for AIS)

2c 75 μm aperture

(5-hole aperture for AIS mode, of that 3 apertures also suitable as normal condenser apertures)

Position 3: 20 μm or 30 μm EDX "cap" aperture

Objective lens aperture	(Contrast aperture) Aperture holder: Position 1: 90 μm Position 2: 60 μm Position 3: 30 μm
Selector aperture (Option)	(also selected-area or intermediate-image aperture) Aperture holder: Position 1: 200 μm Position 2: 100 μm Position 3: 50 μm
Goniometer	to move the specimen
Prevacuum signal lamp	(not visible) During specimen lock-in/out it displays non-attained prevacuum for lock-in. See also section 4.10.2.
Specimen rod	to accommodate max. 2 different specimens. See also section 4.10.1.
Specimen changer	2 positions Large knurled knob to coarsely shift the specimen holder to either of the two positions. Small knurled knob to secure in the corresponding position.
Gun	If the column is ventilated it can be swung out after pushing the key on the gun lift, e.g. for filament exchange.
Gun lift	(pneumatic)
Anticontaminator	principle: contamination in the specimen chamber is stopped by condensing of hydrocarbons on the cold surface near the specimen. The anticontaminator is cooled down to approx. 100 K. Fill Dewar vessel with approx. 1 l liquid nitrogen. (sufficient for approx. 5 hours). See also section 1.2.4.
Spectrometer	Omega electron-energy filter Elimination of inelastically scattered electrons by elastic filtering by the omega filter. The spectrometer consists of four magnetic prisms and one hexapole/quadrupole corrector in the symmetry plane.
Spectrometer Entrance aperture (Spectrometer Aperture diaphragm)	Equipment of aperture holder Position 1: 1000 μm Position 2: 650 μm Position 3: 100 μm

Slit aperture for slit selection and adjustment	<ul style="list-style-type: none"> – Positions: 6 positions in longitudinal direction, to use in case of contaminated edges by aperture shifting to an unused area of the slit) – Adjustment of slit in longitudinal direction and alignment to the energy axis are possible – Variation of slit width See also section 1.4.3.
TV camera port 35mm camera	to mount e.g. a CCD camera and/or 35 mm camera
Viewing microscope	Magnification 9x Diopter adjustment for ametropic users separately for each eyepiece.
Large fluorescent screen	can be raised for photography with the sheet-film camera
Small fluorescent screen	can be raised separately
Beam stop	serves to mask out the bright zero beam of diffraction images for <ul style="list-style-type: none"> – better recognition of the remaining diffraction image – film exposure measurement without zero beam brightness

1.4.2 Aperture drives

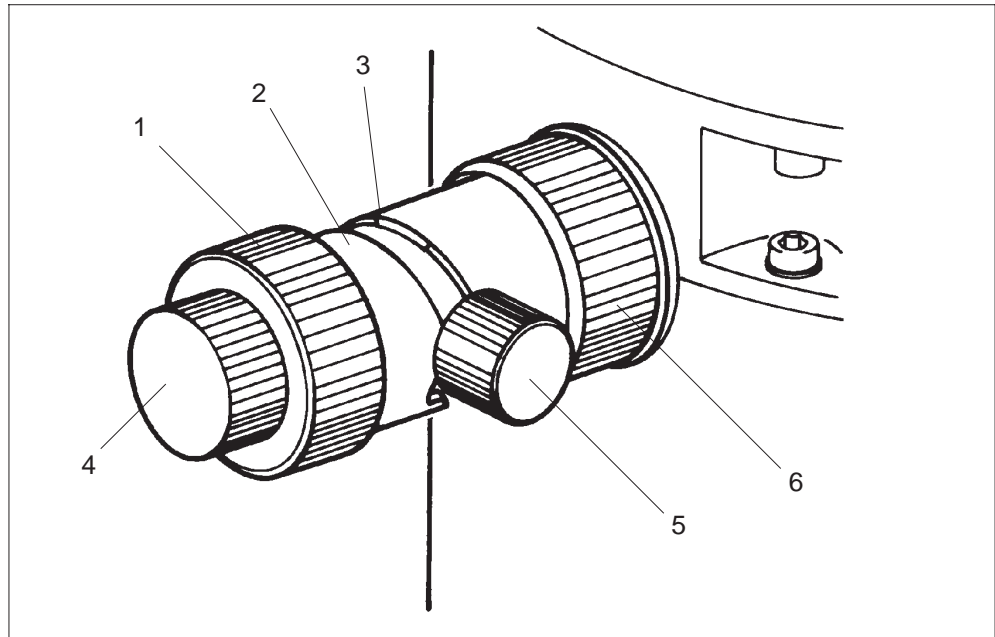


Fig. 1-44: Aperture drive (all apertures except for slit aperture)

The aperture drives serve to quickly exchange and precisely adjust the apertures:

- Condenser aperture
- Objective lens aperture
- Selector aperture
- Spectrometer entrance aperture

The four aperture drives are of the same mechanical design:

- With the large knurled knob (1, Fig. 1-44) on the face of the drive the aperture holder is axially shifted coarsely to the individual aperture positions. The drive engages several notches (3) on the inner edge of guide (2), which defines the different aperture positions.
(See also menu APERTURES, description in section 3.3.1)
Knurled knob turned fully counterclockwise: aperture not in beam path
Position ascending with clockwise rotation
- The small knurled knobs on face (4) and side of drive (5) are used like micrometer screws for the precision shift of the aperture to the corresponding aperture positions (e.g. for centering).
Knurled knob (4) on the face shifts the aperture image on the fluorescent screen from left to right; knob (5) at the side shifts it up and down.
- The knurled ring on the column (6) acts as retaining ring which secures the aperture drive to the column.

1.4.3 Slit aperture drive

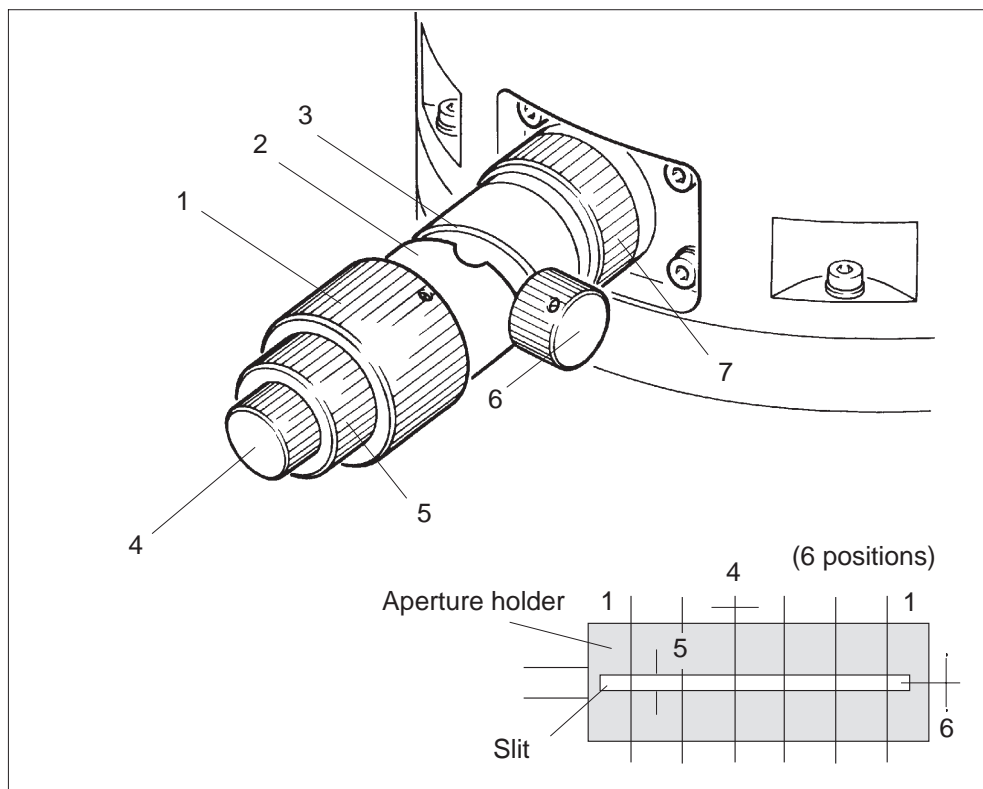


Fig. 1-45: Slit aperture drive

With the slit aperture drive you select the slit area and precisely adjust the slit aperture. The mechanical design is described below, the possible adjustments are shown in Fig. 1-45.

- With the large knurled knob (1, Fig. 1-45) on the front of the drive the aperture holder can be shifted longitudinally in 6 positions. Notches (3) inside guide (2) let the drive snap in at the individual positions.
- With the small knurled knob (4) on the front the aperture is precisely adjusted in longitudinal direction.
- Knurled knob (5) in the middle serves to vary the slit width of the aperture.
- The slit is adjusted in the energy axis with the small knurled knob (6) at the side of the drive.
- Knurled ring (7) on the column is a retaining ring which secures the slit aperture drive to the column.

1.5 Power supply cabinet

The power supply cabinet contains the heavy duty electrical components. A built-in ventilator carries off the heat produced during operation. The filter mats before the ventilator which serve as dust covers for the heavy duty electrical components must be regularly cleaned.

The number of instrument starts can be entered in the menu BACKUP ALL. If the input number is attained, the operator is reminded to create a backup disk and clean the filter mats.

The power supply cabinet also contains the main switch, the electrical fuses F1 ... F12 and different electrical connectors.

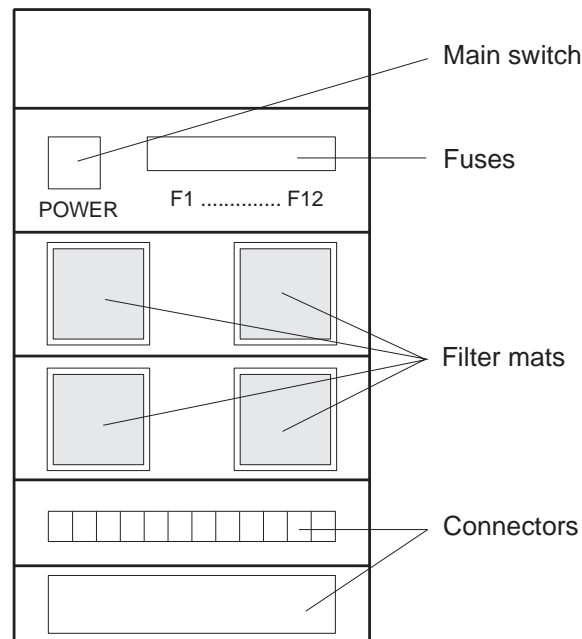


Fig. 1-46: Power supply cabinet of LEO 912 OMEGA

2

Important Information

Table of contents

2	Important Information	
2.1	General information	2-3
2.1.1	Software licence agreement	2-3
2.1.2	Misuse of MS-DOS-run programs	2-3
2.1.3	Service contract	2-3
2.2	Safety precautions	2-4
2.2.1	Safety precautions for the use of beryllium (Be)	2-4
2.2.2	Safety precautions for the use of liquid nitrogen	2-6
2.2.3	X-ray safety	2-8
2.2.4	Electrical safety	2-9
2.3	Important precepts	2-10
2.4	Important prohibitions	2-11
2.5	Maintenance	2-12

2.1 General information

2.1.1 Software licence agreement

The software of the LEO 912 OMEGA Transmission Electron Microscope may be used only in compliance with the provisions of a licence agreement concluded with LEO .

The rights for the use of the LEO 912 OMEGA software delivered with the instrument are laid down in the agreement which must be signed by the customer **before** delivery of the instrument, and becomes integral part of the instrument record.

The data processing programs may be copied only for the intended use and for backup.

2.1.2 Misuse of MS-DOS-run programs

The MS-DOS-based operating system of the LEO 912 OMEGA allows also other MS-DOS-capable programs to be run by the host computers.

The integral computers must **not** be used to run such other programs, because of the risk of malfunctions. LEO guarantees in no event the capability of other programs to be run by the LEO 912 OMEGA operating system. Any attempt by the customer to try to run foreign programs and thus damage the operating system would forfeit the guarantee for the instrument.

2.1.3 Service contract

Only correct care and maintenance of the instrument will assure the best use of the LEO 912 OMEGA (see also section 2.5).

The least maintenance work to be carried out by the user is described in chapter 6 of this manual.

The instructions given in this chapter should be followed reliably and regularly, because only then will correct operation of the LEO 912 OMEGA be guaranteed.

Only if care and maintenance are in compliance with these instructions, will the LEO guarantee apply.

Ask LEO for a corresponding service contract. The service contract and the services rendered by LEO within the framework of the contract will guarantee that the instrument functions properly and helps you to obtain reliable and satisfactory results.

2.2 Safety precautions

2.2.1 Safety precautions for the use of beryllium (Be)

Beryllium is used in the LEO 912 OMEGA for technical reasons, but limited to the absolutely necessary quantity.

Beryllium in the base instrument

The LEO 912 OMEGA is prepared for the attachment of an EDX detector. Beryllium is required in the objective lens area to prevent bremsstrahlung.

With the objective lens closed the user is not directly exposed to Be fine dust or vapor.

- Maintenance work in the objective lens area (exchange of objective lens apertures) and mounting of attachments on the objective lens should be carried out only by the LEO maintenance service.
- The following general notes on the use of beryllium should be strictly observed.

EDX rods made of beryllium

Specimen holder and holding plate of the rods are made of Be. If EDX rods are correctly used, no dust or vapor is generated which would be harmful to your health.

When handling the rod, the following safety precautions should be strictly observed:

- Touching the front end of the rod briefly by mistake is harmless but should be avoided to prevent vacuum breakdown. Use only the prescribed tools for specimen exchange (tweezers, plate lifter).

It is recommended to wear gloves.

- Mechanical polishing, the use of etchants for cleaning, and baking (heating) of the specimen holder are strictly forbidden, because highly toxic dust and vapor may be generated.
- Stop working if abrasion traces are noticeable on the specimen holder.
- Only specialists who know the risks involved in the use of beryllium are allowed to handle the EDX rods (accessibility).
- The rods must be stored in a fireproof, lockable place.
- Please observe the following general instructions for the use of beryllium.



General notes on the use of beryllium (excerpt from the corresponding DIN data sheet)

CAUTION

Beryllium is a highly toxic, easily oxidizable, hard metal. Animal experiments have proved it to be cancerogenic. Beryllium is especially dangerous if it enters the body through the respiratory system in the form of dust or vapor. Serious allergic and chronic poisoning symptoms will appear, followed by severe organic lesions. The effects of the poisoning may appear even many years after exposition.

- Suitable safety measures must be taken for all kinds of processing likely to produce beryllium dust or vapor (grinding, sawing, soldering) or soluble beryllium compounds (mordant, etchant). No such processing is required in the LEO 912 OMEGA.
- Short-time, barehanded contact with clean Be parts (surfaces) is harmless, but gloves should be worn for handling Be parts.
- Do not eat, drink and smoke in the working area.
- Store Be parts fireproof and well locked (e.g. in metal containers).

First aid in case of accidents and fire

- If Be got into contact with bare skin, immediately rinse the corresponding skin area with water (barehanded contact with clean Be parts is harmless but should be avoided).
- Cuts by Be parts must instantly be seen by a doctor and cleaned.
- If Be comes in contact with the eye, immediately wash off with plenty of water and consult a doctor.
- Immediately call a doctor in case of accident or indisposition.
- Do not use water or CO₂ for fire fighting but dry sand, common salt, graphite powder, quick lime or special extinguishing media for burning metal.

Waste disposal

Beryllium-containing parts must be specially disposed of as toxic waste, in compliance with the relevant legal and local provisions.

2.2.2

Safety precautions for the use of liquid nitrogen

The anticontaminator, an attachment of the LEO 912 OMEGA, uses liquid nitrogen. It must be refilled at least once a day. 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.

The following risks are particularly important:



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 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.



CAUTION

Explosion risk if liquid nitrogen penetrates between the walls of the Dewar vessel!



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 20vol% (normally approx. 21vol%).

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.

2.2.3

X-ray safety

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.

It is guaranteed for the LEO 912 OMEGA by a number of active measures (beam current limitation, safety breakers) and passive protection provisions (shieldings) that the permissible maximum doses in compliance with the X-ray rules (RöV) of 01-01-88 are not exceeded, even in case of irregular or faulty operation.

The LEO 912 OMEGA is an approved instrument (in German: *bauartzugelassen*) according to sections 8 through 12 of the new X-ray rules (RöV) of 01-01-88.

In order to get the official approval stamp **approved instruments** have to undergo successfully comprehensive tests conducted by experts of the Physikalisch-Technische Bundesanstalt (PTB). **Two copies of the approval certificate** are supplied with every instrument. Each individual instrument is also subjected to a routine check test; the verified data are not allowed to exceed the limits specified by RöV. We also supply with every instrument our **check test certificate**.

In Germany approved instruments may be operated without the need for permanent X-ray safety control and without any extra permission. X-ray dose limits depend on the intended use of the instrument (see Table 1).

	Category 1	Category 2
RöV as of 1.1.88	1 µSv/h at a distance of 10 cm from the device	7,5 µSv/h at a distance of 10 cm from the device

Table 1: Permissible limits with approved devices

Any instrument which generates X-rays although it is not used for the purpose, is classified by the law into **category 1** (in German: *Störstrahler*). The radiation it emits should not exceed the value specified in Table 1. Any instrument which utilizes the X-ray radiation it generates is classified by the law into **category 2** (in German: *Vollschutzgerät*); the radiation it emits should not exceed the value specified in Table 1. According to RöV, electron microscopes without X-ray spectrometers fall into **category 1**, electron microscopes with energy-dispersive X-ray spectrometers into **category 2**.

The X-ray measurement determines the equivalent dose in Sievert (Sv). The equivalent dose describes the effect of ionizing radiation on the human body.

In Germany owners of instruments falling into category 1 may use these without informing the local authorities, while owners of category 2 instruments must, in compliance with section 4 of RöV, inform the local authorities - in Germany normally the *Gewerbeaufsichtsamt* - **two weeks prior to first start-up**. A copy of the approval certificate must be enclosed with the report. **The user of the instrument is obliged to report**, even if an X-ray spectrometer has been retrofitted.

The approval applies only to the entire instrument, including all column and chamber accessories, as tested by the PTB. The copy of the approval certificate supplied with the instrument specifies the approved accessories. **If the customer equips the instrument with column or chamber accessories not specified in the approval certificate**, or asks our technicians to instal such accessories, **the approval for the entire instrument will expire automatically**. The same applies to modifications of the electron-optical column or the specimen chamber. **In this case the owner must apply to the local authorities** (in Germany: *Gewerbeaufsichtsamt* or *Materialprüfamt*) **for a special permission in compliance with section 3 of RöV**.

These will decide whether a new test and measurement at the user's premises and at his expense are required.



The rules differ only slightly from country to country, but the user has to observe the relevant local provisions.

The following rules must be strictly observed to maintain the X-ray safety of your instrument. Failure to do so may lead to the loss of X-ray safety.

- Do not remove any shieldings, especially near the column of the LEO 912 OMEGA.
- Do not mount non-approved accessories.
The installation of accessories or modifications not specified by the approval certificate will forfeit the approval for the entire instrument. The owner must then apply for a new permission at his expense.
- Do not replace flanges and vacuum components.

2.2.4

Electrical safety

The LEO 912 OMEGA is constructed and tested in compliance with VDE (UL) regulations. Each instrument is tested in the factory for compliance with VDE regulations.

This routine test minimizes the risk of electric shock. There will be not risk for the user if the instrument and the approved accessories are correctly installed and used. In spite of this, certain safety precautions must be observed for the operation of instruments under power.

Recommended Safety installations

- Extra fuse protection by FI switch
- Emergency OFF switch

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.



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 circuit breakers.
- Do not provide for higher fusing of instrument.
- Do not disconnect the instrument.
- Do not buckle, squeeze or cut electrical supply lines.
- Do not use non-approved accessories on the LEO 912 OMEGA.
- De-energize the entire system for servicing.
- **Only authorized specialists** are allowed to work on the electrical system.

2.3 Important precepts

The following precepts should be observed for correct operation of the LEO 912 OMEGA:



- Do not obstruct ventilation ports, cooling surfaces and filters.
- Call the maintenance service in case of incidents or irregularities and switch off the instrument if in doubt.
This prevents extended downtime and expensive repair work.
- Technical operations at the LEO 912 OMEGA may be performed by especially trained LEO engineers only!
- Avoid excessive brightness of the fluorescent screens.
Because of the high flexibility of the LEO 912 OMEGA illumination system exceptionally high beam current densities are adjustable. To protect specimens and instrument (fluorescent screens, detectors) work only without condenser aperture at high beam currents and high illuminating apertures if absolutely necessary.
- All safety precautions described in this chapter and in this manual for the individual working processes must be strictly observed.
This applies in particular to the safety precautions for the use of beryllium, protection against X-rays and provisions for electrical safety.
- The filter mats in the ventilator of the power supply cabinet need regular cleaning to prevent clogging of the filter. This would impair the ventilator flow rate and damage the electronic system by overheating.
- Do not use high illuminating apertures (high beam current) with (optional) LLL cameras (SIT). There is danger of ionization if the images are exceptionally bright.

2.4 Important prohibitions

The following prohibitions should be strictly observed when operating the LEO 912 OMEGA. 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 arcs and strong instabilities.
- Operation of the vacuum system in case of obvious leaks (pressure in the column $> 10^{-6}$ mbar over an extended period, hot ion getter pump (IGP)).
- Force applied to stuck mechanical components (e.g. goniometer drive, sheet-film transport, fluorescent screen lifter).
- To take off shieldings and protective cover sheets.
- To shunt safety breakers (gun), remove electrical fuses and mechanical safety locks and earth leads, and pull plugs (IGP).
- Use of non-approved vacuum grease and pump oil.
- To allow insulators, magnetic material and contamination to enter the vacuum system.
- To load illegally obtained software. Risk of computer viruses! See also "Software licence agreement", section 2.1.1.
- Extended operation of the instrument outside the installation conditions (see chapter 10).
- Baking of instrument or instrument components by the user.
- To mount non-approved attachments.
- To leave data to third parties.

2.5 Maintenance

The following maintenance instructions for the LEO 912 OMEGA should be strictly observed to maintain useability and reliability of the instrument.

Regular care and maintenance of the LEO 912 OMEGA 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 early enough so as not to have any noticeable effect.

Checks and service of the LEO 912 OMEGA should be carried out at regular intervals by our specifically trained service technicians, on the basis of a service contract concluded with LEO . See also section 2.1.3.

Care and maintenance work of the LEO 912 OMEGA which may be carried out by the user himself are described in chapter 6 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 shieldings 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 beryllium and liquid nitrogen, for protection from X-rays and electrical safety must be strictly observed. See section 2.2 of this manual.

Cleaning

The LEO 912 OMEGA 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.
- Use only approved oil and grease for servicing.

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

- Filament and anode replacement
- Cleaning of electrodes and condenser cleaning tube
- Care of specimen holders
- Aperture exchange
- Care of vacuum pump (rotary pump)
- Cleaning of air filter mats in power supply cabinet
- Preparation of backup copies of data records

Note:

For a detailed description of the service measures see chapter 6 of this manual.

3

Menu Guidance

Table of contents

3	Menu Guidance	
3.1	Introduction	3-3
3.1.1	Menu guidance	3-3
3.1.2	The menu system	3-5
3.1.3	Keyboard functions	3-6
3.2	Menu START	3-9
3.3	Main menu	3-11
3.4	Menu PARAMETERS	3-15
3.4.1	Menu CALIBRATION	3-18
3.4.2	Menu USER	3-20
3.4.3	Menu LENS PROGRAM	3-22
3.4.4	Menu MACRO (option)	3-26
3.4.5	Menu APERTURES	3-30
3.4.6	Menu UTILITIES	3-31
3.4.7	Menu INTERF. SETUP	3-35
3.4.8	Menu FOCUS PARAMETERS	3-38
3.4.9	Menu DARKFIELD	3-44
3.4.10	Menu AIS ADJUST (Automatic Illumination Selection)	3-47
3.4.11	Menu MICRO DOSE FOCUSING (option)	3-52
3.4.12	Menu MEASURE	3-56
3.5	Menu GUN	3-59
3.5.1	Menu GUN PAR	3-63
3.6	Menu GONIOMETER	3-68
3.6.1	Menu GON PAR	3-72
3.6.2	Menu POSIT. SERIES (option)	3-74
3.6.3	Menu MATRIX (for option POSITION SERIES)	3-77
3.7	Menu CAMERA	3-79
3.7.1	Menu CAMERA (sheet-film camera)	3-79
3.7.2	Menu 35MM CAMERA (option)	3-83
3.7.3	Menu CAM SETTING (sheet-film camera)	3-87
3.7.4	Menu CAM SETTING (35mm camera) (option)	3-91
3.7.5	Menu EXPOS. SERIES (option)	3-94

3.8	Menu VACUUM	3-97
3.8.1	Standard vacuum system	3-97
3.8.2	Vacuum system with option "2nd ion getter pump"	3-100
3.9	Menu δE	3-103
3.9.1	Menu δE PARAMETERS	3-106
3.9.2	Menu SER EELS	3-108
3.10	Menu IMAGE (option)	3-111

3.1 Introduction

3.1.1 Menu guidance

The control and operating program of the LEO 912 OMEGA, the control monitor and the softkeys provide for interactive user guidance. Menus are displayed on the monitor which consist of:

- the information area where the host computer supplies information to the user on the monitor
- the operation area where the user communicates with the host computer by means of the softkeys and the keyboard.

The example below is the menu GUN:

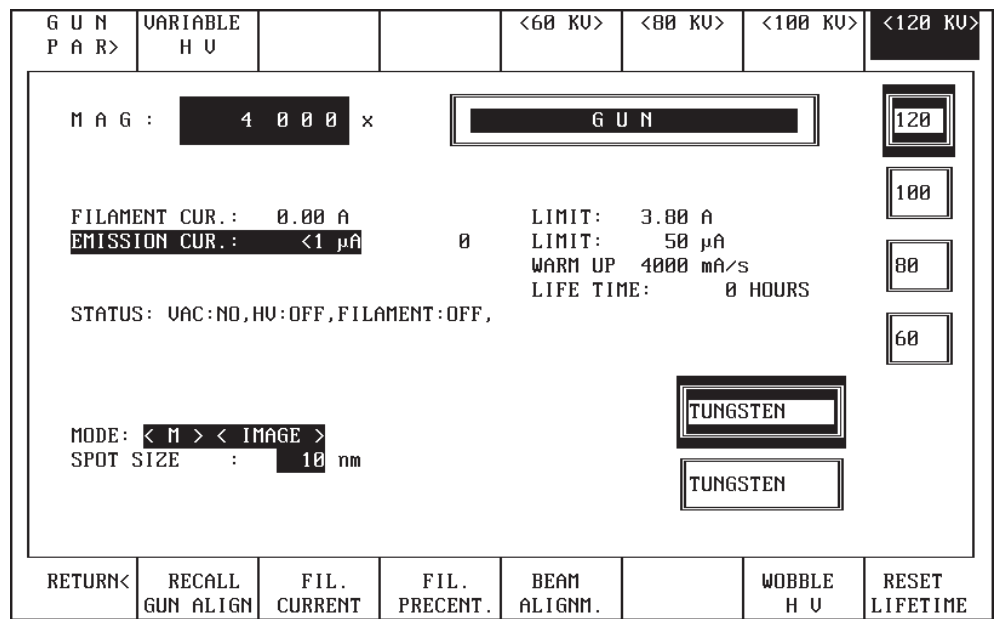


Fig. 3-1 Menu GUN

The information area

is headed by the name of the menu and

- displays menu-specific operating parameters in clear text or graphics. It informs the user about the most important settings of the base instrument and of the subsystem in the corresponding menu.
- gives operating instructions, if necessary.

The operation area consists of

- two rows of eight function keys each arranged above and below the monitor, and
- two rows of eight defined fields in the top and bottom margins of the monitor. Each field is assigned to the opposite softkey and bears the name of the function. Spaced text refers to a submenu, unspaced to functions. A function is activated by pushing the corresponding softkey. Via monitor the user may obtain further instructions, e.g. concerning inputs from the keyboard.

Only clear text is used. At a glance the user sees the status of the microscope or a specific subsystem; special knowledge of operating system or programming is not necessary. Menu-driven operation reduces to a minimum the number of operating controls on the instrument. These may be of the multi-function type and do not impair the clear arrangement of the operating fields.

Besides menu-activated functions there are others activated by function keys from the keyboard. One of the keyboard functions is HELP. A brief explanation of each menu and its softkeys can be displayed on the monitor.

Activation of the HELP menu:

- Activation of HELP text
On the keyboard hold down key <ALT> and push function key <F1>:
HELP text and description of actual menu are displayed.
- Pushing any function key displays the description of the function activated by the key.
- Deactivation of HELP text
Key <ESC> on keyboard pushed:
HELP text deactivated
Menu reactivated.

All other keyboard functions are described in section 3.1.3.

3.1.2 The menu system

The graphics below display the tree structure of the menu system.

The instrument reacts to switch-on by the START menu (see section 3.2) suitable e.g. to copy programs and user data from the hard disk of the host computer on 3.5" floppies. Operating the START key of the menu activates the main menu (see section 3.3) of the real microscopy program.

The trunk of the tree is the main menu which displays the most important operating parameters of electron optics, goniometer and camera and is used to preselect various operating modes.

Each subcomputer has its own menu for data input and data lists. Most frequently used are

- Main menu
- GONIOMETER menu
- CAMERA menu

The tree ramifies from the subsystem branches to menus for special methods and the adjustment of variables.

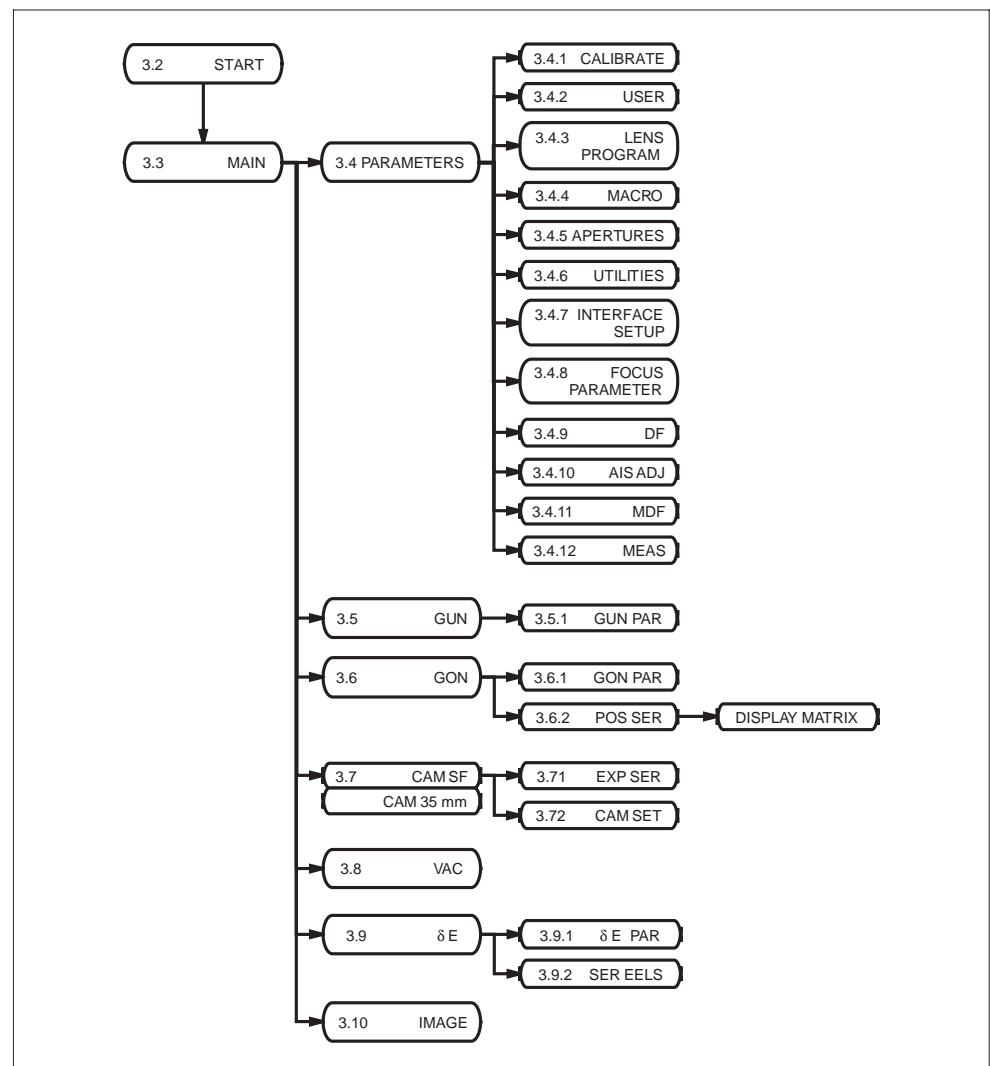


Fig. 3-2: Menu overview

3.1.3

Keyboard functions

Some functions may be called from the keyboard integrated in the control panel:

HELP function

A brief explanation may be called of each menu and key function.



- On the keyboard push the key <ALT> and the function key F1.
The selected menu is explained.
- Push any function key above or below the monitor.
The corresponding key function is explained.
- Push the key <ESC> on the keyboard.
The HELP function is deactivated. The system is reset to the last adjusted operating menu.

Remote mode deactivation

Activated remote control by an external computer blocks operation of the LEO 912 OMEGA by the operating controls. The character line REMOTE is displayed in the right margin. Remote mode can be deactivated from the keyboard.



- On the keyboard push key <ALT> plus function key F2
Remote mode is deactivated.

Exposure interrupt

Film exposure of the sheet-film camera may be interrupted, especially with long exposure times.



- Push function key F3 on the keyboard.
Film exposure is interrupted.

Printout of instrument parameters

The actual status of the LEO 912 OMEGA, i.e. the adjustment of all lens currents and encoders can be printed in the form of a list (see below), provided a printer interface and a printer are connected.



- On the keyboard push key <ALT> plus function key F4.

Numbers without dimensions are digital encoder values.

```

DATE/TIME: 22.10.1997 / 10.07.17

MAGNIFICATION M      :      250000

SPOT SIZE            :      3.2 nm

HIGH TENSION / KV   :      120

C1 - LENS CURRENT   :      3732      ;      4739 mA
C2 - LENS CURRENT   :      1627      ;      2066 mA
C3 - LENS CURRENT   :      2382      ;      1629 mA
OBJ - LENS CURRENT   :      3815      ;      5357 mA
OBJ.- FINE - "      :      1370      ;      619 µA
OBJ.- DEFOCUS "     :      2048

P1 - LENS CURRENT   :      2920      ;      1997 mA
P1 - FINE - "       :      2048      ;      2821 µA
P2 - LENS CURRENT   :      2914      ;      3700 mA
P3 - LENS CURRENT   :      2415      ;      1651 mA
P4 - LENS CURRENT   :      3008      ;      4407 mA
U - REF.            :      4095      ;      10000 mV
C3 - STIG - X       :      2048
C3 - STIG - Y       :      2048
OBJ - PF - STIG - X :      1771
OBJ - PF - STIG - Y :      2629
OBJ - STIG - X      :      1747
OBJ - STIG - Y      :      2143
P1 - STIG - X       :      2048
P1 - STIG - Y       :      2048
BEAM ALIGNMENT - X :      2939
BEAM ALIGNMENT - Y :      2366
FILAMENT - PREC.- X :      1188
FILAMENT - PREC.- Y :      1589
A I S - X           :      2084
A I S - Y           :      2078
DARKFIELD-TILT-X   :      2048
DARKFIELD-TILT-Y   :      2048
ILL. - TILT - X     :      2021
ILL. - TILT - Y     :      1983
ILL. - SHIFT - X    :      2032
ILL. - SHIFT - Y    :      2136
IMAGE - SHIFT - X   :      2039
IMAGE - SHIFT - Y   :      1838
MDF - SHIFT - X     :      2048
MDF - SHIFT - Y     :      2048

```

A small icon of a keyboard key with the text 'F10' on it, enclosed in a rounded square border.**Display illumination switch-off**

- Push function key F10 on the keyboard.

Reactivation:

- Push function key F10 or space key

All other function keys and function key combinations of the keyboard are functionless.

3.2 Menu START

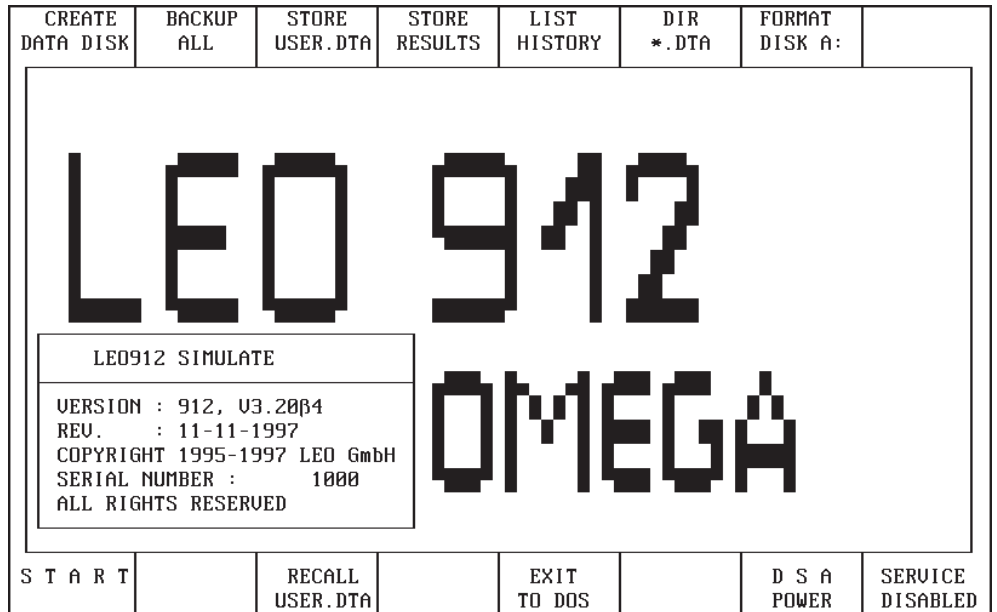


Fig. 3-2

The START menu is displayed on the monitor after LEO 912 OMEGA start-up. Return to DOS operating system with key <ESC> on the keyboard. The operating and control program for the LEO 912 OMEGA must be reloaded after pushing the key <ESC>. Proceed as follows:

- Enter "EM912 OMEGA" from the keyboard.
- Terminate input by pushing <ENTER>.

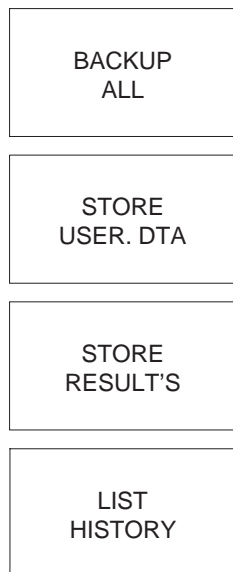
The softkeys of the START menu

All LEO 912 OMEGA programs and data sets are stored on floppy disks

Storage of selected user data set (1-8) on floppy disks

Storage of measured values stored in CAMERA.TXT and MEASURE.TXT files on floppy disks

List of the last 100 error codes



DIR
*.DTA

List of file names and directories on the hard disk
Effect like DOS command *dir*

FORMAT
DISK A:

Disk formatting
for 1.44MB



WARNING:

Data stored on disk are lost during formatting.
Use only High Density (HD) disks with a storage capacity of 1.44MB.

START

Displays the main menu of the LEO 912 OMEGA operating and control program

RECALL
USER.DTA

User data on floppy disk is copied to internal LEO 912 OMEGA hard disk (selection 1 ... 8).

For new USER data select and load the desired user (1-8) from the USER menu.
Only then will the new USER data be available!

EXIT
TO DOS

Exit to DOS operating system

The operating and control program of the LEO 912 OMEGA remains memory-resident.

Return to LEO 912 OMEGA program:

- Enter "EXIT" from the keyboard.
- Terminate input by pushing <ENTER>.

DSA
POWER

Supplies power to the DSA Scanning Attachment

Displayed only with built-in attachment.

3.3 Main menu

P A R >	G U N >	G O N >	C A M >	U A C >	δ E >	I M A G E >	E X I T <
MODE: < M > < I M A G E >				SPECIMEN POSITION:			
M A G : 6 3 0 0 x				X = +6 9 3 3 μm		Y = +6 9 3 3 μm	
ILLUM. MODE: < T E M > < B F >				Z = +6 9 3 3 μm		θ = -8 2.0 °	
ILLUM. ANGLE : 0.10 mrad							
HIGH VOLTAGE: 120.00 kV							
EMISSION CUR. : < 1 μA							
δE: 0 eV							
FOCUS STEP: 120 nm				EXP. TIME: sec			
DEFOCUS: 0 nm				FIX TIME: 38.2 sec			
				FILM SUPPLY: 20			
M / L M MODE		BEAM BLANKER	D F MODE	A I S MODE	M D F MODE	DISPLAY DEFOCUS	D S A

The main menu is displayed on the monitor when the softkey START is operated in the START menu.

The softkeys of the main menu are used to select various illumination and imaging modes and to call submenus. Important and currently used operating parameters are displayed:

- Illumination and imaging modes
- Magnification, high voltage and emission current
- Size of illuminating aperture or luminous spot
- Focus step and defocus value
- Goniometer coordinates (X, Y, Z and Θ , optional Φ or ϵ with special specimen holders)
- Exposure time and film supply
- Energy loss values



SPECIAL NOTE:

The IMAGE menu is only displayed, if the option IMAGE is installed which is automatically delivered with the LEO SSCCD camera. For other SSCCD cameras the IMAGE option must be ordered separately.



SPECIAL NOTE:

The host computer automatically presets the operating parameters of the instrument and the instrument is in the presetting status of the time of switch-off.

PAR

The softkeys of the main menu

Softkey PAR

Used to call the menu PARAMETERS (see section 3.4).

The digital values of the active encoder functions are displayed by a graph in the menu PARAMETERS and further submenus can be called.

GUN

Softkey GUN

Used to call the GUN menu (see section 3.5).

High voltage and beam alignment settings are made in the GUN menu.

GON

Softkey GON

Used to call the GONIOMETER menu (see section 3.6).

Settings for goniometer control are made in the GONIOMETER menu.

CAM

Softkey CAM

Used to call the CAMERA menu (see section 3.7).

It is used to

- adjust the exposure conditions
- enter the imprint for the negative
- call the submenus EXPOSURE SERIES and CAMERA SETTING

VAC

Softkey VAC

Used to call the VACUUM menu (see section 3.8).

It displays the status of the vacuum system and is used for its operation. Shown are

- the valve positions in a schematic view of the vacuum system
- the vacuum pressures of the system
- the status codes which are also displayed by the vacuum LCD on the left control panel.

δE

Softkey δE

Used to call the menu δE (see section 3.9).

In the menu δE all settings are needed for operation and control of energy loss imaging.

IMAGE

Softkey IMAGE

Used to call the menu IMAGE (see section 3.10).

It includes additional functions such as:

- Additional brightness control
- Shutter selection for the SSCCD camera
- DISPLAY DEFOCUS
- OVERVIEW mode
- MDF mode (Micro Dose Focusing)
- BEAM BLANKER
- CALIBRATE DOSE RATE
- and other options

EXIT

Softkey EXIT

Used for exit from LEO 912 program and return to START menu. The actual instrument settings are automatically stored on the hard disk.

The LEO 912 OMEGA can be switched off only if the START menu is displayed on the monitor after using the EXIT key. Only then the actual instrument settings will be stored and reactivated with the next program call.

M / LM
MODE

Softkey M / LM MODE

Used to change between the magnification modes M and LM.

- M refers to <Magnification> or standard magnification (high objective lens excitation),
- LM refers to <Low Magnification> (low objective lens excitation).
- The actual mode is displayed on the monitor.

The objective lens aperture must be removed from the beam path because it limits the image field when operating in the LM MODE.

Condenser and stigmator settings are stored separately in M and LM modes.

BEAM
BLANKER

Softkey BEAM BLANKER

Used to blank the beam above the specimen.

Purpose: Specimen protection because of unnecessary irradiation.

DF
MODE

Softkey DF MODE

It is active only in magnification (M) mode and used to change between brightfield and darkfield imaging.

In <darkfield> mode the electron beam is tilted depending on the amount of illumination offset.

- Function activated: key field highlighted.
- Input of illumination offset in DARKFIELD or CAMERA menu.

AIS
MODE

Softkey AIS MODE

It is active only in magnification (M) mode and used to change to automatic selection of the luminous field diaphragm. AIS stands for **A**utomatic **I**llumination **S**election. Depending on the magnification the AIS system selects from a multi-hole aperture an aperture which provides for a specimen illumination which is only inconsiderably larger than the imaged specimen area. The multi-hole aperture must be removed for full illumination of the fluorescent screen at magnifications < 8 000x.

Function activated: key field highlighted.

MDF
MODE

Softkey MDF MODE (option)

It is active only in magnification (M) mode and used to change to **Micro Dose Focusing**. In MDF mode an off-axis object area is illuminated and imaged for focusing. The electron beam then jumps back to the optical axis for exposure.

- Function activated: key field highlighted.
- Input of size and direction of axial shift in the MDF menu.

DISPLAY
DEFOCUS

Softkey DISPLAY DEFOCUS

The function DISPLAY DEFOCUS displays a manual defocus e. g. for photography.

After activating the function DISPLAY DEFOCUS the focus display is set to zero, but the objective lens current is not changed. If the focus is then changed with the focus knob, the actual defocus is displayed on the menu and on the negative.

The previous defocus program is automatically deactivated.

When the objective lens is calibrated, the function DISPLAY DEFOCUS is deactivated and the previous defocus program is active again. This also will happen, if the function DISPLAY DEFOCUS is switched off manually.

This function is also available in the FOCUS PAR menu and in the IMAGE menu.

DSA

Softkey DSA (option)

Used to change between TEM and STEM modes.

3.4 Menu PARAMETERS

CAL>	USER>	LENS PGM>	MACRO	>	APER- TURE>	UTI>	INTER FACE>
MAG : 4000 x		PARAMETER					
EMISSION_CURRENT >>>		ILL_SHIFT_M_X >>>		ILL_SHIFT_M_Y >>>		COARSE_FOCUS >>>	
CONDENSER_FOCUS >>>		IMAGE_SHIFT_M_X >>>		IMAGE_SHIFT_M_Y >>>		FILTER_VERT_SHIFT >>>	
MODE: <M> <IMAGE>		SPOT SIZE : 10 nm		EMISSION CUR. : <1 μA		DIGITAL POSITIONS	
RETURN<		FOCUS PAR>		DF>		AIS ADJ>	
MDF>		MEAS>		GUN ILL.X ILL.Y FOCUS C FOCUS IMAGE X IMAGE Y		2093 2130 3036 2412 2136 2102 2628	

The menu is used to

- graphically display the digital values of the principal parameters adjusted by the encoders on the control panel. The selection of the displayed parameters depends on the operation mode of the instrument (1 digit of the focus display corresponds to 4nm).
- call further menus.

Softkey CAL

Used to call the CALIBRATE menu (see section 3.4.1).

The menu is used to reset all actual instrument settings and parameters to factory-set values.

The menu also includes the reset keys for the independently operating processors GONIOMETER, GUN and CAMERA.

Softkey USER

Used to activate the USER menu (see section 3.4.2.).

The menu is used to store and recall eight user-specific instrument settings and parameters.

Softkey LENS PGM

Used to call the menu LENS PROGRAM (see section 3.4.3).

From this menu a lens program for each high voltage step can be called up. With the option FREE LENS CONTROL one additional lens program for change by the user becomes available.

CAL

USER

LENS
PGM

MACRO

Softkey MACRO (option)

Used to call the menu MACRO (see section 3.4.4).

The menu is used to write, save and call macros.

Macros are a series of different stored instrument settings which may be called any number of times using the function keys F1 to F8.

APER-
TURES**Softkey APERTURES**

Used to call the menu APERTURES (see section 3.4.5).

The menu is for information only. It displays all data concerning the set-up of the aperture drives, which may be changed at the user's choice.

UTI

Softkey UTI

Used to call the menu UTILITIES (see section 3.4.6).

It includes additional functions such as:

- Entry for backup reminder (EDIT BACKUP CALL)
- Amplitude adjustment for for FOCUSING AID
- Additional brightness control
- different options

I'FACE
SETUP**Softkey I'FACE SETUP (for optional connections)**

Used to call the menu INTERF.SETUP (see section 3.4.7).

The menu is used to define the transmission parameters of the RS232 interfaces 1 to 4.

RETURN

Softkey RETURN

Used to return to the main menu.

FOCUS
PAR**Softkey FOCUS PAR**

Used to call the menu FOCUS PARAMETERS (see section 3.4.8).

The menu is accessible only in magnification mode M and imaging mode IMAGE.

In the menu the following parameters are adjusted:

- Focus mode
- Focus step
- Defocus mode
- Defocus value

DF

Softkey DF

Used to call the DARKFIELD menu (see section 3.4.9).

The menu is accessible only in magnification mode M.

In the menu

- the 5 different DF offset values are adjusted and displayed
- special DF functions can be selected.

AIS
ADJ

Softkey AIS ADJ

Used to call the menu AIS ADJUST (see section 3.4.10).

AIS refers to **A**utomatic **I**llumination **S**election.

The menu is accessible only in AIS mode activated from the main menu.

The AIS parameters are adjusted in the menu AIS ADJUST.

MDF

Softkey MDF (option)

Used to call the menu MICRO DOSE FOCUSING (see section 3.4.11).

The menu can be called only in magnification mode M.

In the menu

- the offsets for MDF mode are adjusted and the digital values of deflection and redeflection displayed
- special MDF functions are activated.

M E A S

Softkey MEAS (option)

Used to call the menu MEASURE (see section 3.4.12).

Depending on adjustment and imaging mode length, angle or interplanar spacing are measured in the image in the menu MEASURE.

3.4.1

Menu CALIBRATION

				RESET G U N	RESET G O N	RESET C A M	
M A G : 4 0 0 0 x				C A L I B R A T I O N			
MODE: < M > < I M A G E > SPOT SIZE : 10 nm EMISSION CUR.: < 1 μA							
RETURN<	CALIBR. IM. SHIFT	CALIBR. ILL. DEFL	CALIBR. FOCUS	CALIBR. MAG	CALIBR. IM. STIG	CALIBR. ILL. STIG	CALIBR. A L L

From this menu factory settings of all instrument parameters can be restored. The following general operating parameters are displayed on the monitor:

- Magnification
- Magnification and imaging modes
- Illuminating aperture

**SPECIAL NOTE:**

The calibration values are entered in the factory using 100kV, so that different offsets from the ideal adjustment are possible at different high-voltage steps.

RESET
G U N

Softkey RESET GUN

Used to reset the beam generation subsystem to the factory setting (hardware reset).

RESET
G O N

Softkey RESET GON

Used to reset the goniometer subsystem to the factory setting (hardware reset).

RESET
C A M

Softkey RESET CAM

Used to reset the camera subsystem to the factory setting (hardware reset).

RETURN

Softkey RETURN

Used to return to the menu PARAMETERS.

CALIBR.
IM. SHIFT

Softkey CALIBR. IM. SHIFT

Used to reset the image shift to the factory-adjusted value, but only for the adjusted imaging mode (IMAGE or DIFFRACTION) or spectrometer mode (IMAGE or SPECTRUM).

CALIBR.
ILL. DEFL

Softkey CALIBR. ILL. DEFL

Used to reset the image tilt or shift to the factory-adjusted value, but only for the adjusted illumination mode (TILT or SHIFT).

CALIBR.
FOCUS

Softkey CALIBR. FOCUS

Used to reset the objective lens current to the factory-adjusted value.

The objective lens current (C3 current value in SPOT mode) is set at first to the maximum and then to the factory-adjusted value which in spite of hysteresis assures reproducibility of the adjustment.

CALIBR.
MAG

Softkey CALIBR. MAG

Used to reset the projector lens current to the factory-adjusted value.

The values are set at first to the maximum and then to the factory-adjusted values which in spite of hysteresis assures a reproducibility of the magnification adjustment of better than 3%.

CALIBR.
IM. STIG

Softkey CALIBR. IM. STIG

Used to reset the current value of the imaging stigmator to the factory-adjusted value but only for the adjusted imaging mode (M/LM, M-DIFF/LM-DIFF).

CALIBR.
ILL. STIG

Softkey CALIBR. ILL. STIG

Used to reset the current of the illumination stigmator to the factory-adjusted value but only for the adjusted illumination mode (TEM, SPOT).

CALIBR.
ALL

Softkey CALIBR. ALL

Used to calibrate all factory settings.

3.4.2

Menu USER

EDIT USER NAME	STORE USER PAR.			USER 1 Test	USER 2	USER 3	USER 4
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;"> U S E R </div>							
RETURN<	RECALL USER PAR.			USER 5	USER 6	USER 7	USER 8

The menu is used to store and retrieve user-specific data and instrument settings. Eight different memories can be assigned to a softkey under a defined user name. Pushbutton-operated instrument settings are stored on hard disk, e.g. before work is interrupted, and the same state of the instrument re-established after an interruption. The user data are loaded from and stored on floppy disk in the START menu.

Softkey EDIT USER NAME

Used to enter a user name for a selected USER number. When the key is operated the cursor on the monitor flashes for 10s and asks for input.

- ENTER the name from the keyboard (max. 9 characters) and push <ENTER> to terminate the input. The name is displayed in the key field of the selected USER softkey.
- If the input is not terminated with <ENTER> the name is automatically taken over to the key field after 10s, which ends the input.

Softkey STORE USER PAR.

Used to store on the hard disk the parameters of the actual instrument setting under the selected user number. When the key is operated OVERWRITE MEMORY ? is displayed.

- Answering with Y from the keyboard stores the user-specific instrument settings.
- Answering with N from the keyboard or making no input within 10s deactivates the enquiry menu.

EDIT
USER NAME

STORE
USER PAR.

USER 1

to

USER 8

RETURN

RECALL
USER PAR

Softkeys USER 1 to USER 8

Used to select the USER number (key field highlighted).

The following softkeys may now be activated for a selected user:

- EDIT USER NAME: defines the name of the selected user.
- RECALL USER PAR.: activates the instrument settings saved under the selected user.
- STORE USER PAR.: stores the actual instrument settings on the hard disk under the selected user.

Softkey RETURN

Used for return to the menu PARAMETERS.

Softkey RECALL USER PAR.

Used to call the instrument setting stored under the selected user number.

- Softkey pushed:
 - The data of a user-specific instrument setting are loaded from the hard disk. The LEO 912 OMEGA program comes back with the START menu.
 - As in switch-on the user-specific instrument setting is activated with the START key.
 - User-specific data are loaded from the floppy disk in the START menu.

3.4.3 Menu LENS PROGRAM

FREE MAG	FREE COND	EDIT MAG VAL.	EDIT NAME				
MAG : 6 3 0 0 x				LENS PROGRAM			
CURRENT LENS PROGRAM: << 8 >> ,LEO 912 120 kV							
	NUMBER	NAME					STATUS
<< 1 >>	LEO 912	60 kV					RESERVED
<< 2 >>	LEO 912	80 kV					RESERVED
<< 3 >>	LEO 912	100 kV					RESERVED
<< 4 >>	LEO 912	120 kV					RESERVED
<< 5 >>	LEO 912	60 kV					FREE
<< 6 >>	LEO 912	80 kV					FREE
<< 7 >>	LEO 912	100 kV					FREE
<< 8 >>	LEO 912	120 kV					FREE
MODE: < M > < IMAGE >							
ILLUM. ANGLE : 0.10 mrad							
EMISSION CUR.: <1 µA							
RETURN<	SELECT LENS PGM	COPY LENS PGM					

The menu is used to select one out of 8 lens programs.

If the option FREE LENS CONTROL is installed the parameters of the lens programs 5 to 8 are changeable by the menus FREE MAGNIFICATION ADJUST and FREE CONDENSER ADJUST.

Softkey FREE MAG (option)

Displayed only with installed option FREE LENS CONTROL.

It activates the menu FREE MAGNIFICATION ADJUST for the previously selected lens program (programs 5 to 8 only!).

Here, the projector lens current values of the actual lens program can be changed.

Softkey FREE COND (option)

Displayed only with installed option FREE LENS CONTROL.

It activates the menu FREE CONDENSER ADJUST for the previously selected lens program (programs 5 to 8 only!).

Here, the condenser current values of the actual lens program can be changed.

FREE
MAG

FREE
COND

EDIT
MAG VAL.



Softkey EDIT MAG VAL. (option)

Used to enter the magnification values in lens programs 5 to 8.

SPECIAL NOTE:

The key is defined only with installed option FREE MAG. CONTROL or FREE LENS CONTROL.

- Softkey pushed:
 - The input field MAG is displayed on the monitor.
 - The cursor asks for input.
- ENTER the magnification from the keyboard.
- Input terminated from the keyboard with <ENTER>.
 - The input is taken over to the display field MAG. If <ENTER> is not operated the input is automatically terminated 10s after input of the last character.

EDIT
NAME



Softkey EDIT NAME (option)

Used to enter the names in lens programs 5 to 8.

SPECIAL NOTE:

The key is defined only with installed option FREE MAG. CONTROL or FREE LENS CONTROL.

- Softkey pushed: the cursor asks for input in the name area of the display field CURRENT LENS PROGRAM.
- ENTER the name from the keyboard. 30 characters are allowed, except for ä, ö, ü and ß.
- Input terminated from the keyboard with <ENTER>. The input is taken over to the display field in the monitor center. If <ENTER> is not operated the input is automatically terminated 10s after input of the last character.

RETURN

Softkey RETURN

Used for return to the menu PARAMETERS.

SELECT
LENS PGM

Softkey SELECT LENS PGM

Used to select a lens program.

- Softkey pushed:
 - Key field highlighted.
 - Displayed are two selector keys for two lens programs (examples 4 and 8).

An invariable and a variable lens program is offered. The assignment depends on the adjusted high voltage.

High voltage	invariable lens program	variable lens program
60V	<<1>>	<<5>>
80V	<<2>>	<<6>>
100V	<<3>>	<<7>>
120V	<<4>>	<<8>>



SPECIAL NOTE:

The high voltage is selected by the menu HV/FIL SELECT (see section 3.5.1).

- Push selector key. Parameters and name of variable lens programs 5 to 8 are now variable using the softkeys EDIT MAG VAL. and EDIT NAME, and by the menus FREE MAG ADJ. and FREE COND ADJ..

FREE MAG	FREE COND	EDIT MAG VAL.	EDIT NAME																															
<div style="border: 1px solid black; padding: 5px;"> <p>MAG : 6 3 0 0 × LENS PROGRAM</p> <p>CURRENT LENS PROGRAM: << 8 >> ,LEO 912 120 kV</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>NUMBER</th> <th>NAME</th> <th>STATUS</th> </tr> </thead> <tbody> <tr><td><< 1 >></td><td>LEO 912 60 kV</td><td>RESERVED</td></tr> <tr><td><< 2 >></td><td>LEO 912 80 kV</td><td>RESERVED</td></tr> <tr><td><< 3 >></td><td>LEO 912 100 kV</td><td>RESERVED</td></tr> <tr><td><< 4 >></td><td>LEO 912 120 kV</td><td>RESERVED</td></tr> <tr><td><< 5 >></td><td>LEO 912 60 kV</td><td>FREE</td></tr> <tr><td><< 6 >></td><td>LEO 912 80 kV</td><td>FREE</td></tr> <tr><td><< 7 >></td><td>LEO 912 100 kV</td><td>FREE</td></tr> <tr><td><< 8 >></td><td>LEO 912 120 kV</td><td>FREE</td></tr> </tbody> </table> <p>MODE: < M > < IMAGE ></p> <p>ILLUM. ANGLE : 0.10 mrad</p> <p>EMISSION CUR.: <1 μA</p> </div>								NUMBER	NAME	STATUS	<< 1 >>	LEO 912 60 kV	RESERVED	<< 2 >>	LEO 912 80 kV	RESERVED	<< 3 >>	LEO 912 100 kV	RESERVED	<< 4 >>	LEO 912 120 kV	RESERVED	<< 5 >>	LEO 912 60 kV	FREE	<< 6 >>	LEO 912 80 kV	FREE	<< 7 >>	LEO 912 100 kV	FREE	<< 8 >>	LEO 912 120 kV	FREE
NUMBER	NAME	STATUS																																
<< 1 >>	LEO 912 60 kV	RESERVED																																
<< 2 >>	LEO 912 80 kV	RESERVED																																
<< 3 >>	LEO 912 100 kV	RESERVED																																
<< 4 >>	LEO 912 120 kV	RESERVED																																
<< 5 >>	LEO 912 60 kV	FREE																																
<< 6 >>	LEO 912 80 kV	FREE																																
<< 7 >>	LEO 912 100 kV	FREE																																
<< 8 >>	LEO 912 120 kV	FREE																																
RETURN<	SELECT LENS PGM	COPY LENS PGM																																

PROGRAM
<< 1 >>

to

PROGRAM
<<4>>

COPY
LENS PGM

CANCEL

PROGRAM
<< 5 >>

to

PROGRAM
<< 8 >>

Softkeys PROGRAM << 1 >> to PROGRAM <<4>>

Used to activate one of the invariable lens programs 1 to 4 (HV-dependent).

The lens program selector keys disappear after program selection.

Blocked are the functions FREE MAG, FREE COND, EDIT MAG VAL. and EDIT NAME selectable by the softkeys in the upper block. If any of these softkeys is pushed, the error message appears: »Nur in den Linsenprogrammen 5 bis 8 möglich« (possible only in lens programs 5 to 8).

The error message disappears when any softkey is pushed.

Softkey COPY LENS PGM

Used to copy program parameters and names of the lens program displayed in the line CURRENT LENS PROGRAM on the monitor into either one of the HV-dependent lens programs 5 to 8.

- Softkey pushed:
 - Key field highlighted.
 - Selector keys for lens programs 5 - 8 are displayed.
- Push the desired selector key.
 - Parameters and name are copied to the selected lens program and displayed in the general field.

Softkey CANCEL

Used to reset the SELECT or COPY mode.

This key is displayed only if either SELECT LENS PGM or COPY LENS PGM was pushed.

- Softkey CANCEL pushed: the keys for lens program selection disappear. SELECT LENS PGM or COPY LENS PGM must be pushed again for any other selection.

Softkeys PROGRAM << 5 >> to PROGRAM <<8>>

Used to select any of the variable lens programs 5 to 8 (HV-dependent).

The selector keys for the lens programs disappear after program selection.

The functions FREE MAG, FREE COND, EDIT MAG VAL. and EDIT NAME selectable by the softkeys in the upper block can be activated.

3.4.4 Menu MACRO (option)

SELECT FILE	SAVE AS	STORE FILE		SELECT F× FUNC.	EDIT F× FUNC.		
<div style="border: 1px solid black; padding: 5px; margin: 0 auto; width: 150px;">M A C R O</div>							
FILE TO LOAD :		USER1.MCR					
ACTIVE FILE :		USER1.MCR					
F1		R1T024T001T005T022T038T003S10106S10010T017S2102000T025R0J					
F2		R1R0J					
F3		R1R0J					
F4		R1R0J					
F5		R1R0J					
F6		R1R0J					
F7		R1R0J					
F8		R1R0J					
RETURN<		LOAD FILE					

In the use of the LEO 912 OMEGA a series of operating steps is often repeated or functions are needed in one menu which can only be activated in another.

The function MACRO will be helpful in such cases.

A macro is a series of instrument settings adjustable by operating controls or menus. Such series of operating steps may be saved on a function key (F 1 to F8) and called up any time. A macro may consist of one or several settings.

Softkey SELECT FILE

Used to select a file in the directory "C:\EM\TEXT" with the extension .MCR (e.g. MACRO.MCR). Displayed is the file content in the field SELECTED FILE.

Softkey SAVE AS

Used to save the actual file under a new name.

- Softkey pushed: the blinking cursor in the field CURRENT FILE asks for input.
- ENTER file name (extension .MCR) from the keyboard (max. 8 characters + .MCR).
- Terminate input with <ENTER>.

If <ENTER> is not operated the entry is automatically terminated 10 seconds after input of the last character.

SELECT
FILE

SAVE
AS

STORE
FILE

Softkey STORE FILE

Used to store the actual file.

STORE
Fx FUNC

Softkey SELECT Fx FUNC

Used to select any of the function keys F 1 to F8 to edit the MACRO function.

- Softkey pushed: the selector bar is moved to the next key (F1 to F8). The next function key is selected every time the key is pushed.

EDIT
Fx FUNC

Softkey EDIT Fx FUNC

Used to edit the MACRO function on the selected function key.

The content of the file "MACRO.MCR" is automatically loaded on the function keys with system start-up.

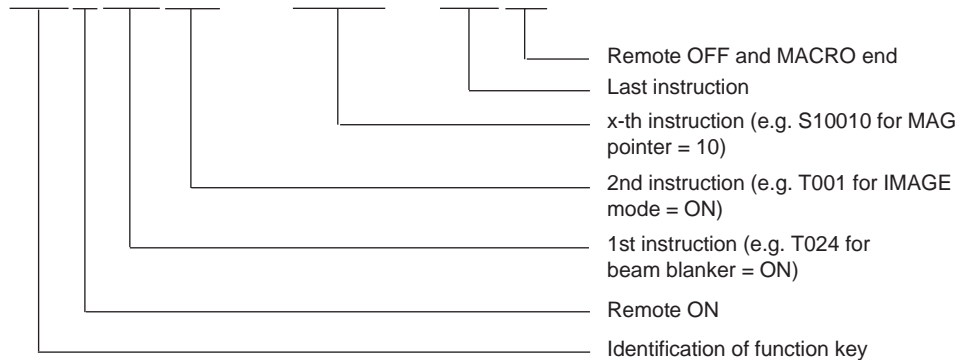
The following syntax is required for macro input:

- Each macro starts with "R1" for Remote ON.
- Each macro ends with "RO]" for Remote OFF and MACRO end (]).
- An additional identification of the function keys is automatically saved in the file. \$Fx\$ is the identification for function key x (e.g. \$F1\$ for function key F1).
- All SET (S) and TASK (T) functions from the Remote list can be used in a macro (for Remote list see separate documentation).

Example:

File content:

\$F1\$R1T024T001....S10010...T025RO]



An example of a reasonable assignment of the function keys for user-oriented MDF is given on the following pages.

RETURN

Softkey RETURN

Used to return to the menu PARAMETERS.

Softkey LOAD FILE

Used to load a selected file.

- Softkey pushed: the macro stored on the selected function key is displayed in field SELECTED FILE.

Assignment of function keys F1 to F8

Macros for user-oriented MDF:

```
# F1 key = Search mode
#
# BeamBlanker = ON          T024
# IMAGE mode = ON          T001
# MAG mode = MAG           T005
# AIS mode = ON            T022
# MIS mode = OFF           T038
# Ill mode = TEM           T003
# Ill pointer = 6 (0.06mrad) S10106
# MAG pointer = 10 (8000)  S10010
# MDF mode = OFF           T017
# DelayTime = 2000         S2102000
# BeamBlanker = OFF        T025

$F1$R1T024T001T005T022T038T003S10106S10010T017S2102000T025R0 ]

# F2 key = Focus mode
#
# MDF mode = ON            T016
# BeamBlanker = ON        T024
# Mag pointer = 15 (25000) S10015
# Ill pointer = 16 (0.5 mrad) S10116
# MIS Select = 0           S2090
# MIS mode = ON            T037
# DelayTime = 2000         S2102000
# BeamBlanker = OFF        T025

$F2$R1T016T024S10015S10116S2090T037S2102000T025R0]

# F3 key = Photo mode
#
# BeamBlanker = ON        T024
# MIS mode = OFF           T038
# MDF mode = OFF           T017
# FreeExposure= ON        T317
# DelayTime = 2000         S2102000
# SetBeamTime = 2000       S2072000
# MDF mode = ON            T016
# FreeExposure= OFF        T318
# MIS mode = ON            T037
# DelayTime = 2000         S2102000
# BeamBlanker = OFF        T025

$F3$R1T024T038T017T317S2102000S2072000T016T318T037S2102 000T025R0]
```

```

# F4 key = Photo Test mode
#
# BeamBlanker = ON          T024
# MIS select = 3           S2093
# MDF mode = OFF          T017
# SetBeamTime = 2000      S2072000
# MDF mode = ON          T016
# MIS Select = 0          S2090

$F4$R1T024S2093T017S2072000T016S2090R0]

# F5 key
#
# Adjust MAG mode          T005
# Adjust IMAGE mode        T001
# Adjust TEM mode          T003
# Set MAG pointer to step 10 S10010

$F5$R1T005T001T003S10010R0]

# F6 key
# Adjust MAG mode          T005
# Adjust IMAGE mode        T001
# Adjust TEM mode          T003
# Set MAG pointer to step 20 S10020

$F6$R1T005T001T003S10020R0]

# F7 key
# Adjust MAG mode          T005
# Adjust IMAGE mode        T001
# Adjust SPOT mode         T004
# Set SPOT pointer to step 10 S10110

$F7$R1T005T001T004S10110R0]

# F8 key
# Adjust MAG mode          T005
# Adjust IMAGE mode        T001
# Adjust SPOT mode         T004
# Set SPOT pointer to step 15 S10115

$F8$R1T005T001T004S10115R0]

```


3.4.5

Menu APERTURES

M A G : 6 3 0 0 x								A P E R T U R E S	
APERTURE :		POS 1	POS 2	POS 3	POS 4				
CONDENSER		-----	400	5 - HOLE	20	µm			
PREFIELD		-----	20	-----	-----	µm			
OBJECTIVE		-----	90	60	30	µm			
INTERMEDIATE		-----	200	100	50	µm			
ENTRANCE		-----	2000	800	100	µm			
SLIT									
MODE: < M > < IMAGE >									
ILLUM. ANGLE :		0.10 mrad							
EMISSION CUR. :		<1 µA							
RETURN<	EDIT CONDENS.	EDIT PREFIELD	EDIT OBJECTIVE	EDIT INTERMED.	EDIT ENTRANCE	EDIT SLIT			

The menu shows the set-up of the aperture drives; its function is merely that of a “notebook”. Each entry may consist of max. 8 characters and is changeable. A table with 6 lines for max. 6 apertures (APERTURE NO. 1 to APERTURE NO. 6) is displayed on the monitor. The lines are divided into 4 columns from POS 1 to POS 4, which are assigned to the max. 4 positions of an aperture holder. The assignment of APERTURE 1 to 6 to the apertures actually installed in the instrument is not compulsory.

Softkey RETURN

Used for return to the menu PARAMETERS.

Softkeys EDIT CONDENSER APERT. to EDIT SLIT APERT.

Used to edit the 4 entries for the apertures condenser to slit.

- Softkey pushed: the cursor asks for input in field POS 1. If no input is made within 10 seconds, the cursor jumps automatically to the next position and asks for input.
- Make entries in fields POS 1 to POS 4 (8 characters except for ä, ö, ü and ß) and terminate with <ENTER>. If <ENTER> is not operated the entry is automatically terminated 10 seconds after input of the last character.

RETURN

EDIT
CONDENS.

to

EDIT
SLIT

3.4.6 Menu UTILITIES

	EDIT BAC. CALL			IMAGE ROTATION	H R MODE	FOCUS AID D O W N	FOCUS AID U P
<p>M A G : 4 0 0 0 x UTILITIES</p> <p>START UP TIMES : 30</p> <p>MODE: < M > < IMAGE > SPOT SIZE : 10 nm EMISSION CUR. : < 1 μA</p> <p>EXP. TIME: sec FIX TIME: 2.4 sec FILM SUPPLY: 02</p>							
RETURN<	CONST. BRIGHTN.	BEAM BLANKER	X <--> Y		ILL. SHIFT F I N E	BRIGHTN. FINE	

The menu is used to activate various functions such as CONSTANT BRIGHTNESS or BEAM BLANKER, and call supplementary functions such as ILL. SHIFT FINE and BRIGHTN. FINE and special functions like IMAGE ROTATION. Exposure time and film supply are also displayed.

Softkey EDIT BAC. CALL

Used for input of the number of system starts for backup reminder.

Before the START menu is displayed the user is requested to copy the user and/or system data on floppy disk and clean the filter mats in the power supply cabinet.

- Softkey pushed: the cursor in the field START UP TIMES asks for input.
- From the keyboard enter a number between 1 and 99 for the number of system starts.
- From the keyboard terminate input with <ENTER>. If <ENTER> is not operated the input is automatically terminated 10 seconds after input of the last character.

EDIT
BAC. CALL

LM Y
AID

Softkey LM Y AID

to change the wobbler direction.

In LM mode the change of the wobbler direction allows compensation of astigmatism in addition to exact focusing.

Procedure

Focusing:

- Key AID pushed.
- Set image displacement to minimum with encoder FOCUS OBJECTIVE.

Compensation of astigmatism:

- AID activated.
The specimen is wobbled in the X direction.
- Select menu UTILITIES.
- Softkey LM Y AID activated.
The specimen is wobbled in the Y direction.
The image displacement (specimen shift) should be the same in the Y and in the X direction, or minimize image displacement with the encoders IMAGE, STIG X, Y for the X and Y directions.

IMAGE
ROTATION

Softkey IMAGE ROTATION (option)

Used to activate the function IMAGE ROTATION for adapting an oblong specimen structure to the photographic format.

The function IMAGE ROTATION changes the excitation of projector lens P4. The lens is operated at the focal-length minimum, but changing the lens current will, besides providing image rotation, also slightly change the magnification. The magnification change may be max. 15%. If the analyzer slit has been correctly aligned, the magnification change may cause vignetting which can be compensated by varying the slit width.

- Softkey pushed: key field highlighted.
- ENTER the desired image rotation with encoder SPOT FOCUS in the field BRIGHTNESS and release exposure.
 - The rotation value is reset with magnification or brightness change, but the functions remains active. Readjust the rotation value.
- Softkey pushed again: key field illumination off.
 - The rotation value is reset.

The function is automatically deactivated and the rotation value reset with exit from the menu UTILITIES.

HR
MODE



FOCUS AID
DOWN

FOCUS AID
UP

RETURN

CONST.
BRIGHTN.

Softkey HR MODE

Used to activate the HR illumination mode for high magnifications.

In activated HR mode the illumination system is automatically switched from three-step crossover reduction to single-step crossover reduction. The switch-over is only made for illuminating apertures > 1.6mrad.

- Softkey pushed: key field highlighted.
- HR illumination mode is activated for:
 - Illuminating apertures > 1.6mrad
 - Magnifications > 125 000x

SPECIAL NOTE:

HR mode is activated also at magnifications > 4 000x and < 125 000x, but the AIS system is switched off. The image is then cut off at magnifications < 125 000x and the use of the AIS aperture.

Softkey FOCUS AID DOWN

Used to reduce the wobble amplitude of the focusing aid. (Key AID in the field FOCUS to wobble the direction of irradiation.) The amplitude is reduced by one step every time the key is pushed. The amplitude is best adjusted in the imaging mode DIFFRACTION with the selected objective lens aperture. The wobbler amplitude should not be higher than the diameter of the objective lens aperture in use.

Softkey FOCUS AID UP

Used to increase the wobble amplitude of the focusing aid. (Key AID in the field FOCUS to wobble the direction of irradiation.) The amplitude is increased by 1 step every time the key is pushed. The amplitude is best adjusted in DIFFRACTION mode with the selected objective aperture. The wobbler amplitude should not be higher than the diameter of the objective lens aperture in use.

Softkey RETURN

Used for return to the main menu.

Softkey CONST. BRIGHTN.

Used to activate the brightness adjustment with magnification change. The illuminating aperture is automatically readjusted with each magnification change so that the image is displayed on the fluorescent screen with approximately constant brightness. CONSTANT BRIGHTNESS activated: key field highlighted.

Increase in magnification means increasing exposure of the specimen to the electron beam !

BEAM
BLANKER

Softkey BEAM BLANKER

Used to activate the beam blanker before the specimen area of interest.

Purpose: shorter exposure from the electron beam. Function on: key field highlighted.

CCD CAM.
ACTIVE

Softkey CCD CAM. ACTIV. (option)

Used to activate the GATAN wide-angle-CCD camera.

- Softkey pushed: key field highlighted.
- The CCD camera is pneumatically brought into the beam path.
- Pushing the key again moves the camera back to normal position.

PN TV
ACTIVE

Softkey PN TV ACTIVE (option)

Used to turn in pneumatically the optics for a TV camera.

ILL SHIFT
FINE

Softkey ILL SHIFT FINE

Change of ILL. SHIFT encoder X, Y to SPOT fine shift ($\pm 25\text{nm}$)

Used for precise fine shift for exact positioning of the spot on a small image feature.

- Softkey pushed: key field highlighted.
- Positioning of the spot on a small specimen feature (area $\pm 25\text{nm}$) referred to the fluorescent screen.
- The function is automatically deactivated with exit from the menu.

BRIGHTN.
FINE

Softkey BRIGHTN. FINE

Used to activate an optional function for fine adjustment of variable image brightness which is in excess of the standard control by the zoom condenser.

3.4.7 Menu INTERF. SETUP

SELECT DOWN	SELECT UP	NEXT				INIT. INTERFACE
<div style="border: 1px solid black; padding: 5px; display: inline-block;">INTERF. SETUP</div>						
INTERFACE : 1 2 3 4 5						
BAUDRATE : 2400 9600 9600 2400 9600						
PARITY : 0 0 0 0 0						
DATABITS : 8 8 8 8 8						
STOPBITS : 2 2 2 2 2						
PARITY : 0 = NONE, 1 = ODD, 2 = EVEN						
RETURN<		SETUP-1 REMOTE1	SETUP-2 REMOTE2	SETUP-3 STEMREM	SETUP-4 STEMKEY	SETUP-5 RS232

The menu is used to define the transmission parameters of the five serial interfaces (RS232). The following interfaces can be installed:

- 1 and 2 (REMOTE 1 and 2): Remote-control interfaces 1 and 2
- 3 (STEMREM): remote-control interface DSA
- 4 (STEMKEY): keyboard interface DSA
- 5: presently not in use.

The following transmission parameters must be defined:

BAUDRATE: 300, 600, 1,200, 2,400, 4,800, 9,600 or 19,200 baud
 PARITY: 0 = none, 1 = odd, 2 = even
 DATABITS: either 7 or 8
 STOPBITS: either 1 or 2.

SELECT
DOWN

Softkey SELECT DOWN

Used to skip to the next lower value in the list of parameter values.

SELECT
UP

Softkey SELECT UP

Used to skip to the next higher value in the list of parameter values.

NEXT

Softkey NEXT

Used to skip to the next parameter in the column of the selected interface.

INIT.
INTERFACE

Softkey INIT. INTERFACE

Softkey pushed: The parameters listed on the monitor are transmitted to the interfaces and become effective.

RETURN

Softkey RETURN

Used to return to the menu PARAMETERS.

SETUP-1
REMOTE1

Softkeys SETUP-1 REMOTE1 and SETUP-2 REMOTE2

Used to define the parameters for the interfaces 1 and 2 (REMOTE 1 and 2).

and

SETUP-2
REMOTE2

- Softkey pushed: the entry for BAUDRATE in the 1st (interface 1) or 2nd column (interface 2) is highlighted.
- Go through the baudrate values using the softkeys SELECT DOWN or SELECT UP until you find the value you want.
- With softkey NEXT take over selected value as new entry. Luminous bar skips to next entry (PARITY) which may now be changed as described above.
- Make entries for DATABIT and STOPBIT accordingly.
- Softkey INIT. INTERFACE pushed: parameters in the 1st or 2nd column become effective for the interface.

SETUP-3
STEMREM

Softkey SETUP-3 STEMREM

Used to define the parameters for interface 3 (STEM-REMOTE).

- Softkey pushed: entry for BAUDRATE in the 3rd column highlighted by a luminous bar.
- With the softkeys SELECT DOWN or SELECT UP go through the baudrate values until the desired value is found.
- Take over the selected value as new entry with the softkey NEXT. The luminous bar skips to the next entry (PARITY) which may now be changed as described above.
- Make the entries for DATABIT and STOPBIT accordingly.
- Softkey INIT. INTERFACE pushed: the parameter values in the 3rd column are effective for interface 3.

SETUP-4
STEMKEY

Softkey SETUP-4 STEMKEY

Used to define the parameters for interface 4 (STEM-KEYB.)

- Softkey pushed: entry for BAUDRATE in the 4th column highlighted by a luminous bar.
- Proceed as described above for softkey SETUP-3.

SETUP-5
RS232

Softkey SETUP-5 RS232

Used to define the parameters for interface 5 (not in use).

- Softkey pushed: entry for BAUDRATE in the 5th column highlighted by a luminous bar.
- Proceed as described above for softkey SETUP-3.

3.4.8 Menu FOCUS PARAMETERS

DISPLAY DEFOCUS	CHECK DEFOCUS	WOBBLE OBJECTIVE					
M A G : 2 0 0 0 0 x F O C U S P A R A M .							
FOCUS STEP MODE: M A G . - D E P E N D I N G F O C U S S T E P							
FOCUS STEP: 36 nm							
DEFOCUS MODE: O F F							
DEFOCUS: 0 nm							
MODE: < M > < I M A G E >							
ILLUM. ANGLE : 0.10 mrad							
EMISSION CUR.: < 1 μA							
RETURN<	MAG.-DEP. DEFOCUS	FIXED DEFOCUS	SELECT DEFOCUS	SCHERZER DEFOCUS	MAG.-DEP. FOC. STEP	FIXED FOC. STEP	SELECT FOC. STEP

The menu is used to adjust the focus and defocus values.

The menu can be called only with activated IMAGE mode and magnification mode M.

Displayed on the monitor are:

- Focus mode
- Focus step
- Defocus mode
- Defocus

A high reproducibility for focusing is obtained if defocusing is made by the host computer: the specimen is focused by the focusing aid (key AID). The selected defocus value is adjusted by the computer during exposure. The following defocus adjustments are possible:

- SCHERZER DEFOCUS (high-voltage-dependent)
- MAGNIFICATION DEPENDENT DEFOCUS
- FIXED DEFOCUS (free choice)
- USER DEFOCUS

If none of the keys is activated (defocus mode off) the exposure is made with the individually adjusted focus value.

The imaging mode cannot be changed from this menu. Exit from this menu if this is wanted.

DISPLAY
DEFOCUS

Softkey DISPLAY DEFOCUS

Used to display the manual defocus in the menu and in the data block of the negative.

After activating the function DISPLAY DEFOCUS the focus display is set to zero, but the objective lens current is not changed. If the focus is then changed with the focus knob, the actual defocus is displayed on the menu and on the negative.

The previous defocus program is automatically deactivated.

When the objective lens is calibrated, the function DISPLAY DEFOCUS is deactivated and the previous defocus program is active again. This also will happen, if the function DISPLAY DEFOCUS is switched off manually.

This function is also available in the MAIN menu and in the IMAGE menu.

CHECK
DEFOCUS

Softkey CHECK DEFOCUS

Used to test the adjusted defocus on the specimen.

- Push the softkey.
- The objective lens is adjusted to the selected defocus value between two beeps. The binoculars must be used for observation. The test may be repeated as often as necessary.

WOBBLE
OBJ. FOC.

Softkey WOBBLE OBJ. FOC.

Used to wobble the objective lens current for adjustment of the objective lens center of rotation (e.g. in HR mode).

Only in the ideal case is the center of rotation of the objective lens coincident with the high-voltage center. The best image is obtained by exactly aligning the beam incidence to the high-voltage center.

- Center and focus specimen detail.
- Push softkey.
 - Key field highlighted.
 - The additional softkey ADJUST WOB. AMPL. is displayed. (Vary the wobblers amplitude with encoder FOCUS OBJECTIVE).
 - The objective lens current is wobbled.
- Minimize object shift with encoder ILLUMINATION TILT X, Y.

Deactivation: Softkey WOBBLE OBJ. FOC. pushed again.



SPECIAL NOTE:

The function WOBBLE OBJ. FOC. is **not** deactivated with exit from the menu.

ADJUST
WOB. AMPL.

Softkey ADJUST WOB. AMPL.

Used to adjust the amplitude of the focus wobbler.

The softkey is displayed only if the focus wobbler was activated with the softkey WOBBLE OBJ. FOC.

- Softkey pushed.
 - Key field highlighted.
 - The encoder OBJECTIVE in the field FOCUS now has the function “adjust wobbler amplitude”.
- Adjust wobbler amplitude with encoder.
- Softkey pushed again or exit from menu: the function is deactivated.

CONTIN.
FOCUS

Softkey CONTIN. FOCUS

Used to select the operating mode “continuous focusing” for the encoder OBJECTIVE. At the limit of the fine focus range the key STEP in the field FOCUS does not need to be switched between COARSE and FINE.

The instrument makes the following settings automatically:

- Coarse focus adjustment continued 9 steps up or down.
- Fine focus adjustment set to medium value in the new coarse focus range.

A minor focus jump is noticeable during switch-over.

CO / FINE
FOCUS

Softkey CO / FINE FOCUS

Used to select the operating mode “coarse” or “fine” focus of the encoder OBJECTIVE. At the limit of the fine focus range the key STEP in the field FOCUS should be switched between COARSE and FINE.

- With the key STEP in the field FOCUS switch to coarse focus adjustment and to over- or underfocus.
- With the key STEP switch back to fine focus adjustment and focus back from the new range limit.

RETURN

Softkey RETURN

Used for return to the menu PARAMETERS.

MAG.-DEP.
FOC.STEP

Softkey MAG.-DEP. FOC. STEP

Used to select the mode "magnification-dependent adjustment of focus step".

- Push the softkey.
- The actual mode MAG.-DEPENDENT FOCUS STEP is displayed in the field FOCUS STEP MODE.
- The focus step is automatically adapted to the actual magnification at magnifications from 6,300x to 100,000x (see table).
- Step width at $M < 6,300x$: constant at 120nm
- Step width at $M > 100,000x$: constant at 4nm.

MAG.	MAG. DEP. DEFOCUS		
	LOW	MEDIUM	HIGH
3150	13.2 μm	26.4 μm	51.6 μm
4000	8.4 μm	18 μm	34.8 μm
5000	6 μm	12 μm	24 μm
6300	3.6 μm	8.4 μm	15.6 μm
8000	2.4 μm	4.8 μm	9.6 μm
10000	2 μm	3.6 μm	8.0 μm
12500	1.4 μm	2.6 μm	5.2 μm
16000	900 nm	1.7 μm	3.4 μm
20000	640 nm	1.2 μm	2.4 μm
25000	420 nm	820 nm	1.6 μm
31500	300 nm	552 nm	1.1 μm
40000	200 nm	300 nm	700 nm
50000	140 nm	260 nm	500 nm
63000	96 nm	180 nm	320 nm
80000	64 nm	120 nm	220 nm
100000	44 nm	84 nm	160 nm
125000	28 nm	56 nm	108 nm
160000	20 nm	40 nm	72 nm
200000	12 nm	24 nm	48 nm
250000	8 nm	16 nm	32 nm
315000	4 nm	12 nm	16 nm
400000	4 nm	8 nm	12 nm
500000	4 nm	8 nm	12 nm

FIXED
FOC.STEP



SELECT
FOC.STEP

SCHERZER
DEFOCUS

MAG.-DEP.
DEFOCUS

Softkey **FIXED FOC. STEP**

Used to select the mode "fixed focus step".

- Push the softkey.
 - The actual mode FIXED FOC. STEP is displayed in the field FOCUS STEP MODE.
 - The fine focus step adjusted by SELECT FOC. STEP remains the same over the entire magnification range.
 - Minimum step width: 4nm
 - Maximum step width: 124nm
- Coarse focus: fixed step width of 1,200nm

SPECIAL NOTE:

If a step width is adjusted which is not divisible by 4, the next one divisible by 4 is set.

Softkey **SELECT FOC. STEP**

Used to adjust the step width for FIXED FOCUS STEP mode.

The function can be activated only in FIXED FOCUS STEP mode.

- Softkey pushed: the encoder OBJECTIVE in the field FOCUS now has the function "adjust focus step".
- Adjust step width in 4nm steps with encoder. Range: 4nm to 124nm.
- Function deactivated: push softkey again or exit from menu.

Softkey **SCHERZER DEFOCUS**

Used to activate the Scherzer defocus value during exposure. The dependency of the Scherzer defocus value on the adjusted high voltage is automatically considered as follows:

- High voltage: 60kV 80kV 100kV 120kV
- Defocus value: 120nm 112nm 104nm 100nm

A high reproducibility is assured by defocusing by the host computer: the specimen is focused with the focusing aid (key AID). The selected defocus value is adjusted by the computer during exposure.

Softkey **MAG.-DEP. DEFOCUS**

Used to activate a magnification-dependent defocus value during exposure. Three defocus values can be preselected for each magnification step with the softkey SELECT DEFOCUS: LOW, MEDIUM and HIGH. A low defocus value is adjusted at high magnifications and a higher value at low magnifications. At the step MEDIUM the defocus is doubled compared with LOW. At HIGH a 4-times higher value is adjusted than at LOW. The adjustments are optimized for biological applications.

A high reproducibility is assured when defocusing is done by the host computer: the specimen is focused with the focusing aid (key AID). The computer adjusts the selected defocus value during exposure.

**FIXED
DEFOCUS****Softkey FIXED DEFOCUS**

Used to activate a selectable fixed defocus value for exposure.

High focusing reproducibility is assured by defocusing by the host computer. The specimen is focused with the focusing aid (key AID). The computer adjusts the selected defocus value during exposure.

Adjustment:

- Push also softkey SELECT DEFOCUS.
- With encoder OBJECTIVE select in the field FOCUS a value between 4nm and 64 μ m with 4nm intervals.

**SELECT
DEFOCUS****Softkey SELECT DEFOCUS**

Used to enter the defocus value. Which kind of input is used depends on the selected defocus mode:

Mode MAG.-DEP. DEFOCUS activated:

- Softkey SELECT DEFOCUS switches from LOW to MEDIUM, etc. when pushed.

Mode FIXED DEFOCUS activated:

- Select defocus value with encoder OBJECTIVE in field FOCUS (it now has the function "adjust defocus value"). It may lie between 4nm and 64 μ m (with 4nm intervals) and is displayed on the monitor in the field DEFOCUS.
- Function deactivated: push mode key again or exit from menu.

3.4.9

Menu DARKFIELD

	STORE DF OFFSET	DF -1-	DF -2-	DF -3-	DF -4-	DF -5-	RESET DF OFFSET
MAG : 5 0 0 0 x		D A R K F I E L D					
ILLUMIN.X OFFSET >		-934					
ILLUMIN.Y OFFSET >		-499					
MODE: < M > < IMAGE >							
ILLUM. ANGLE :		0.10 mrad					
EMISSION CUR. :		<1 µA					
RETURN<	A I S MODE	DF MODE	C O N E I L L .	CARTES. COORDIN.	POLAR COORDIN.	ADJUST DF OFFSET	

In “darkfield” mode the electron beam is tilted by an adjustable value from the eucentric axis until the zero beam is masked out by the objective aperture or a selected lattice reflection lies in the center of the aperture. The menu is accessible only in magnification mode M and used to

- adjust and display 5 different DF offset values
- select specific DF functions.

Softkey AUTO LOAD

Used to automatically call the DF offset values stored on the hard disk.

- Softkey pushed:
 - The softkey is highlighted.
 - When either of the 5 DF softkeys is pushed the stored values of the selected DF offset are set and displayed on the monitor in the lines ILLUMINATION OFFSET X or Y.

Softkey STORE DF OFFSET

Used to store the displayed DF offset on the hard disk.

- Softkey pushed: the displayed value of the DF offset is taken over into the selected DF memory (DF softkey highlighted).

AUTO
LOAD

STORE
DF OFFSET

DF
- 1 -

to

DF
- 5 -

RESET
DF OFFSET

RETURN

A I S
MODE

DF
MODE

Softkeys DF -1- to DF -5-

Used to select a memory for each of the DF offsets 1 to 5. The selected softkey is highlighted.

Softkey RESET DF OFFSET

Used to zero the DF offset value of the selected memory.

Softkey RETURN

Used for return to the menu PARAMETERS.

Softkey AIS MODE

Used to switch the AIS mode off and on.

- Softkey pushed.
 - Key field highlighted.
 - AIS mode activated. The condenser aperture assigned to the magnification is centered.
- Key pushed again.
 - Key field not highlighted. The central AIS aperture (37µm dia.) is centered and may be used as selected-area aperture. For magnifications up to 6,300x the AIS mode must be deactivated and the condenser aperture removed for complete illumination of the fluorescent screen.

Softkey DF MODE

Used to change between brightfield and darkfield imaging.

- Softkey pushed:
 - Key field highlighted.
 - Darkfield mode activated.
- Selection of DF offset.
- Softkey pushed again: return to normal brightfield mode

CONE
ILL.

Softkey CONE ILL.

Used to switch to cone illumination.

Cone illumination is a special darkfield mode. In this mode the electron beam rotates about the electron-optical axis on a cone at the tilt angle adjusted in the illumination offset.

- Softkey pushed:
 - Key field highlighted.
 - Cone illumination mode activated.
- Softkey pushed again: return to normal operating mode.
- Input of the illumination offset is possible only with activated ADJUST DF OFFSET and POLAR COORDINATES.

CARTES.
COORDIN.

Softkey CARTES. COORDIN.

Used to select the input mode “cartesian coordinates” for the illumination offset. With this mode an illumination tilt of 5° is adjustable in any direction.

The first call of the menu always activates the mode “cartesian coordinates”. It is then possible to switch to POLAR COORDINATES. The softkey field of the selected coordinate type is highlighted. The DF OFFSET may be input only with activated ADJUST DF OFFSET function.

POLAR
COORDIN.

Softkey POLAR COORDIN.

Used to switch to the input mode “polar coordinates” for the illumination offset with conical illumination.

- Softkey pushed:
 - Key field highlighted.
 - Input mode “polar coordinates” activated. The offset amount for the desired tilt angle of the beam is adjusted by encoder X in the field ILLUMINATION, the offset azimuth angle by encoder Y in the field ILLUMINATION.

ADJUST
DF OFFSET

Softkey ADJUST DF OFFSET

Used to adjust the darkfield offset.

- Softkey pushed:
 - Key field highlighted.
 - Encoders X and Y in the field ILLUMINATION are activated for adjustment of the darkfield offset.

3.4.10

Menu AIS ADJUST (Automatic Illumination Selection)

	ADJUST HR MODE	HR MODE		FREEZE MAG	MIS MODE	MIS SELECT	NEW AIS OFFS.
<p>MAG : 4 0 0 0 x AIS ADJUST</p> <p>AIS STEP : 1</p> <p>MIS STEP : 0</p> <p>AIS UPPER X > 267 0 STIG COR. X > -62</p> <p>AIS UPPER Y > 1209 0 STIG COR. Y > -109</p> <p>AIS LOWER X > 35 TILT COR. X > -88</p> <p>AIS LOWER Y > -1056 TILT COR. Y > -47</p> <p>MODE: < M > < IMAGE ></p> <p>ILLUM. ANGLE : 0.10 mrad</p> <p>EMISSION CUR.: < 1 μA</p> <p style="text-align: center;"><< USE ILLUMINATION KNOBS >></p>							
RETURN<	CALIBR. AIS OFFS.	CONST. BRIGHTN.		ADJUST AIS UPPER	ADJUST AIS LOWER	ADJUST STIG COR.	ADJUST TILT COR.

The menu can be called only if AIS MODE is activated (main menu). The alignment of the 5 AIS steps (AIS 0 to AIS 4) is changed in this menu. Selection of the AIS step either

- automatically with the magnification, or
- manually in MIS mode.

The following assignment for AIS mode is current:

- AIS not active: Magnification 3,150x and LOW MAG (80x to 2,000x)
- AIS 1: Magnification range 4,000x to 12,500x
- AIS 2: Magnification range 16,000x to 25,000x
- AIS 3: Magnification range 31,500x to 50,000x
- AIS 4: Magnification range 63,000x to 100,000x
- AIS 0: Magnification range from 125,000x

CONSTANT BRIGHTNESS mode should be activated for fine adjustment.

Softkey ADJUST HR MODE

ADJUST
HR MODE.

The function is used to enter the correction value for the upper system. The correction is effective only in HR mode, at magnifications ≥ 4,000x and illuminating apertures ≥ 1.6mrad. The correction value is displayed next to the correction value for the AIS UPPER system.

Preconditions:

- Optimized base adjustment of instrument.
- Beam incidence adjusted to center of rotation of objective lens.
- HR mode deactivated.
- AIS 0 aperture centered at 125,000x magnification.

Adjustment:

- Adjustment of 125,000x magnification and illuminating aperture $\geq 1.6\text{mrad}$.
- Objective lens aperture removed from beam path.
- Imaging mode switched to DIFF.
- Diffraction spot exactly aligned to index point with encoder Image Shift.
- AIS mode activated (main menu).
- AIS ADJUST menu selected.
- HR mode activated.
- Key ADJUST HR UPPER pushed.
- Offset of diffraction spot moved to index point with encoder ILL. X, Y.
- Exact coincidence checked by switching HR mode on and off.
- Value stored with STORE AIS OFF.

HR
MODE

Softkey HR MODE

Used to activate the HR illumination mode for high magnifications.

With activated HR mode the illumination system is automatically switched from three-step to single-step crossover reduction. The change is only made for illuminating apertures $\geq 1.6\text{mrad}$.

- Softkey pushed: key field highlighted.
- HR illumination mode is activated for:
 - Illuminating angle $\geq 1.6\text{mrad}$
 - Magnifications $> 125,000\times$



SPECIAL NOTE:

HR mode is active also at magnifications $> 4,000\times$ and $< 125,000\times$. The AIS system is deactivated, and a image cut off occurs at magnifications $< 125,000\times$ and with AIS aperture.

FREEZE
MAG



Softkey FREEZE MAG

Used to freeze the magnification at the actual value. The function presets the AIS values after aperture exchange. All magnification-dependent settings like focus step, AIS STEPS, etc. are not frozen, but executed with the change of the magnification step. The function CONSTANT BRIGHTNESS should be deactivated.

SPECIAL NOTE:

The function FREEZE MAG. is **not** deactivated with exit from the menu.

MIS
MODE

Softkey MIS MODE

Used for manual selection of the AIS steps (MIS stands for Manual Illumination Selection).

- Softkey pushed:
 - Key field highlighted, MIS mode activated. Adjustment of AIS mode impossible.
 - Additional softkey MIS SELECT is displayed.
 - The condenser aperture defining the luminous field is selected with the softkey MIS SELECT independent of the magnification.

MIS
SELECT

Softkey MIS SELECT

Used to select the next AIS step.

The function is displayed only in MIS mode.

NEW
AIS OFFS.



Softkey NEW AIS OFFS.

Used to store on the hard disk as calibration values the actually adjusted AIS offset values of the AIS step. Each AIS step must be stored separately.

SPECIAL NOTE:

The most frequently used high-voltage value should be saved. It is not necessary to save other high-voltage values with this function. Further AIS values are stored on the hard disk automatically and high-voltage-specific.

- Softkey pushed: the enquiry "OVERWRITE CAL AIS VALUES?" is displayed.
 - If answered with Y from the keyboard another enquiry "REALLY OVERWRITE VALUES" is displayed.
 - If answered with Y again the displayed AIS data set is stored on the harddisk.
 - If answering with N or making no input within 10 seconds deactivates the enquiry.

RETURN

Softkey RETURN

Used for return to the menu PARAMETERS.

CALIBR.
AIS OFFS.

Softkey CALIBR. AIS OFFS.

Used to call the stored AIS calibration value for the actual AIS step as initial value for exact correction.

CONST.
BRIGHTN.

Softkey CONST. BRIGHTN.

Used to activate the brightness change with magnification change. The illuminating aperture is automatically readjusted with each magnification change so that the image is displayed on the fluorescent screen with approximately uniform brightness. CONSTANT BRIGHTNESS activated: key field highlighted.

Increase in magnification means increased exposure of the specimen to the electron beam!

ADJUST
AIS UPPER

Softkey ADJUST AIS UPPER

Used to adjust the AIS offset for deflection of the electron beam to the apertures (brightness optimization).

- Softkey pushed: key field highlighted.
- Adjust 5mrad illuminating aperture with key ILL. APERTURE in field BRIGHTNESS.
- Adjust maximum brightness for each AIS step with encoders X and Y in field ILLUMINATION:

ADJUST
AIS LOWER

Softkey ADJUST AIS LOWER

Used to adjust the AIS offset for redeflection of the electron beam to the optical axis (luminous field centration).

- Softkey pushed: key field highlighted.
- For each AIS step center luminous field on fluorescent screen with encoders X and Y in field ILLUMINATION.

ADJUST
STIG COR.

Softkey ADJUST STIG COR.

Used to adjust the AIS offset for correction of illumination astigmatism. Correction of astigmatism is possible only if the softkey is activated.

- Softkey pushed: key field highlighted.
- Activate imaging mode DIFFRACTION on left control panel.
- Through-focus diffraction image.
- Compensate possible astigmatism for each AIS step with encoders X and Y in field ILLUMINATION.

ADJUST
TILT COR.

Softkey ADJUST TILT COR.

Used to adjust the AIS offset for correction of the beam incidence.

- Softkey pushed: key field highlighted.
- Imaging mode DIFFRACTION activated on left control panel.
- Adjust encoders X and Y in field ILLUMINATION for each AIS step so that the diffraction spot lies in the center of the objective lens aperture.

3.4.11

Menu MICRO DOSE FOCUSING (option)

PARALLEL/ FREE		CHECK M D F	M I S MODE	M I S SELECT			RESET MDF OFFS.
M A G : 5 0 0 0 x MICRO DOSE FOCUSING							
M D F ADJUST MODE: FREE DOSE-RATE: NOT-CAL e1/nm ² s							
ILLUMIN.X OFFSET > 0 TILT COR. X > 0							
ILLUMIN.Y OFFSET > 0 TILT COR. Y > 0							
IMAGE X OFFSET > 0							
IMAGE Y OFFSET > 0							
MODE: < M > < IMAGE > EXP.TIME: sec							
ILLUM. ANGLE : 0.10 mrad FIX TIME: 2.4 sec							
EMISSION CUR.: <1 μA FILM SUPPLY: 02							
MDF POS: 1 << USE ILLUMINATION/IMAGE KNOBS >>							
MDF POS: 1 --> MAG: 5000 x							
RETURN<	CALIBRATE DOSE-RATE	BEAM BLANKER	TOGGLE MDF POS	M D F REV. DIR.	M D F MODE	ADJUST MDF OFFS.	ADJUST TILT COR.

The menu is used to

- adjust the offsets for MDF mode and display the digital values of deflection (ILLUMINATION SHIFT) and redeflection (IMAGE SHIFT).
- activate special MDF functions.

To prevent irradiation damage of the specimen MDF uses a specimen area for focusing which is adjacent to the selected specimen area by the MDF offset. The beam is laterally deflected above the specimen (ILL. OFFSET) and the illuminated area redeflected to the optical axis below the specimen (IM. OFFSET) but the electron beam transmits the specimen parallel to the optical axis. The illumination shift provides for a jump of the beam to the area selected for photography only for the time of exposure.

Softkey PARALLEL / FREE

Used to switch the MDF ADJUST MODE from Parallel to Free.

In Free mode the deflection for MDF adjustment may be in any direction. In Parallel mode deflection of the luminous spot is possible only parallel to the goniometer X axis. Even when tilted with the goniometer the specimen remains in focus when switching to MDF.

- Softkey pushed.
- Selected mode displayed under M D F ADJUST MODE.

PARALLEL/
FREE

CHECK
M D F

Softkey CHECK MDF

Used to test the adjusted MDF deflection.

- Softkey pushed:
 - Display: IMAGE OFFSET IS SET TO ZERO !!
 - The beam is set to the adjusted ILLUMINATION X, Y OFFSET. The user can test whether e.g. the luminous field selected for adjustment is outside the photographic format.

M I S
M O D E

Softkey MIS MODE

Used for manual selection of AIS steps (MIS stands for Manual Illumination Selection).

- Softkey pushed:
 - Key field highlighted, MIS mode activated.
 - Additional softkey MIS SELECT is displayed.
 - The condenser aperture defining the luminous field can now be selected with the softkey MIS SELECT independent of the magnification.

M I S
S E L E C T

Softkey MIS SELECT

Used to select the next lower MIS aperture. After MIS step 4 a change is made to MIS step 0. The softkey is displayed only in MIS mode.

R E S E T
M D F O F F S .

Softkey RESET MDF OFFS.

Used to zero ILLUMINATION and IMAGE OFFSET values (no deflection)

- Softkey pushed:
 - The displayed offset values ILLUMINATION X, Y and IMAGE X, Y are zeroed. (In spite of this a minor luminous-field offset is possible between MDF=ON or OFF.)
- New MDF offset adjusted.

R E T U R N

Softkey RETURN

Used for return to the menu PARAMETERS.

BEAM
BLANKER

Softkey BEAM BLANKER

Used to activate the electron beam blanker.

To reduce irradiation of the specimen the electron beam blanker is in this mode activated above the specimen so that the beam does not reach the specimen as long as the function is activated. BEAM BLANKER ON is displayed in the main menu.

- Softkey pushed.
 - Key field highlighted.
 - Beam blanker on.
- Softkey pushed again: beam blanker off.

TOGGLE
MDF POS

Softkey TOGGLE MDF POS

Used to toggle between different MDF settings. Three different presettings are possible. Even the illumination mode AIS or MIS can be stored in the presetting.

M D F
REV. DIR.

Softkey MDF REV. DIR.

Used to reverse the MDF offset (-X, -Y instead of X, Y)

The softkey is displayed only in MDF mode.

M D F
MODE

Softkey MDF MODE

Used to switch to minimum dose focusing.

An off-axis specimen area is illuminated and imaged in MDF mode. The electron beam jumps back to the optical axis for exposure.

- Softkey pushed.
 - Key field highlighted.
 - MDF mode activated.
 - Additional softkey MDF REVERSE DIRECTION displayed.
- Softkey pushed again: return to normal mode.

ADJUST
MDF OFFS.

Softkey ADJUST MDF OFFS.

Used to adjust the MDF offset.

- Softkey pushed: encoder functions switched over.
- Luminous-spot shift adjusted with ILLUMINATION X and Y.
- Beam redeflected to optical axis with IMAGE X and Y. Offset display on the monitor (only with activated MDF mode):
 - Deflection: fields ILLUMINATION X and Y OFFSET
 - Redeflection: fields IMAGE X and Y OFFSET
- Softkey ADJUST MDF OFFS. pushed again or exit from menu:
 - Base functions of encoders restored.

ADJUST
TILT COR.

Softkey ADJUST TILT COR.

Used to correct the beam incidence in MDF mode.

- DIFF mode activated in field IMAGE:

- The diffraction image is displayed on the fluorescent screen. It is normally limited concentrically by the objective lens aperture.

If in MDF position the zero beam in the diffraction image is not concentric to the objective lens aperture, astigmatism may occur in the image, which interferes with the adjustment of the exposure conditions.

- Activate MDF mode with softkey MDF.

- If the zero beam is not centered in the diffraction image, correct beam incidence with ADJUST TILT COR.

- Activate ADJUST TILT COR.

- With encoders X and Y in field ILLUMINATION center zero beam to the objective lens aperture.

- Test exact alignment by repeatedly activating and deactivating MDF mode.

3.4.12

Menu MEASURE

			TWO POINT	THREE POINT	CLEAR MEAS. FILE		AUTO FILE
MAG : 4 0 0 0 x MEASURE							
MODE: < M > < IMAGE > ILLUM. ANGLE : 0.10 mrad EMISSION CUR.: <1 μA							
RETURN<	STORE MES. P1	STORE MES. P2		CALIBR. MAG	CALIBR. IM. SHIFT		RECALL POSIT.

The menu is used to measure distances and angles with the IMAGE SHIFT system. The following measuring programs are available:

Two-point measurement in IMAGE mode:

Measurement of a distance between 2 coordinate pairs.

Output of measured value: Distance in μm .

Two-point measurement in DIFF mode:

Measurement of a distance between zero-order reflection and higher-order reflection.

Output of measured value: diffraction angle in mrad.
Calculated interplanar spacing in nm.

Three-point measurement in IMAGE mode:

Measurement of two distances starting from one point.

Output of measured value: both distances in μm .
Angle formed by the two legs in degrees.
Ratio of distance 1 to distance 2.

Three-point measurement in DIFF mode:

Measurement of two distances between zero-order reflection and two higher-order reflections.

Output of measured value: diffraction angles 1 and 2 in mrad.
Calculated interplanar spacings 1 and 2 in nm.
Angle formed by the reflections.

T W O
P O I N T

Softkey TWO POINT

Used to activate the two-point measuring program.

T H R E E
P O I N T

Softkey THREE POINT

Used to activate the three-point measuring program.

C L E A R
M E A S . F I L E

Softkey CLEAR MEAS. FILE

Used to clear the memory MEASURE.TXT on the hard disk where max. 100 measuring results are automatically stored.

- Save MEASURE.TXT file on floppy disk after each extended measuring series before activating the function.
- Softkey pushed; the enquiry "CLEAR MEAS. FILE" is displayed.
 - Answering with Y from the keyboard clears the MEASURE.TXT file on the hard disk.
- Answering with N or making no input within 10 seconds deactivates the enquiry menu.

A U T O
P R I N T

Softkey AUTO PRINT (option)

Used to activate automatic printout of the measuring results after each measurement. The key field is highlighted with activated function.

A U T O
F I L E

Softkey AUTO FILE (option)

Used for automatic documentation of the measuring results on the hard disk. Max. 100 data sets can be stored in the intermediate memory. Output on the file MEASURE.TXT in the directory C:\EM\TEXT. Copy the file MEASURE.TXT to drive A of a floppy disk after an extended series of measurements using the function STORE RESULTS in the START menu, to prevent measured values from being lost after the 100th value during automatic overwriting. The memory must be cleared with the softkey CLEAR MEAS. FILE after copying to the floppy disk!

- Softkey pushed:
 - Key field highlighted.
 - After each measurement the measuring results are stored on the hard disk.

R E T U R N

Softkey RETURN

Used for return to the menu UTILITIES.

STORE
MES.P1

Softkey STORE MES.P1

Used to define the starting point of measurement. The selected feature must be entirely visible on the fluorescent screen.

- Measuring program TWO POINT or THREE POINT selected.
- Selected feature matched with the size of the fluorescent screen by magnification change and aligned to the screen center.
- First measuring point aligned exactly to the index point with the encoders IMAGE SHIFT X, Y.
- Softkey STORE MES.P1 pushed.
 - Measuring point 1 is stored.

STORE
MES.P2

Softkey STORE MES.P2

Used to define the second measuring point.

- Second measuring point shifted relative to index point with IMAGE SHIFT X, Y.
- Softkey pushed.
 - TWO POINT measuring program: the second measured value is stored. The result is calculated and output. The function CALIBR. IM. SHIFT is activated. The image is reset to calibration position.
 - THREE POINT measuring program: the second measured value is stored.

STORE
MES.P3

Softkey STORE MES.P3

Used to define the third measuring point.

- Third measuring point shifted relative to index point with IMAGE SHIFT X, Y.
- Softkey pushed.
 - THREE POINT measuring program: the third measured value is stored. The result is calculated and output. The function CALIBR. IM. SHIFT is activated. The image is reset to calibration position.

CALIBR.
MAG.

Softkey CALIBR. MAG

Used for reproducible magnification setting of the projector lens system.

CALIBR.
IM. SHIFT

Softkey CALIBR. IM. SHIFT

Used to zero the IMAGE SHIFT system.

RECALL
POSIT.

Softkey RECALL POSIT.

Used to retrieve the displayed saved position. If several successively saved positions are to be retrieved in succession, the function AUTO REC. of the GONIOMETER menu should be activated before (see section 3.6).

To change from one position to the next you need only push this softkey.

3.5 Menu GUN

GUN PAR>	VARIABLE HV			<60 KU>	<80 KU>	<100 KU>	<120 KU>
MAG : 4 0 0 0 x		G U N		120			
FILAMENT CUR. : 0.00 A		LIMIT: 3.80 A		100			
EMISSION CUR. : <1 µA		LIMIT: 50 µA		80			
STATUS: VAC:NO,HV:OFF,FILAMENT:OFF,		WARM UP 4000 mA/S		60			
		LIFE TIME: 0 HOURS					
MODE: < M > < IMAGE >		TUNGSTEN					
SPOT SIZE : 10 nm		TUNGSTEN					
RETURN<	RECALL GUN ALIGN	FIL. CURRENT	FIL. PRECENT.	BEAM ALIGNM.		WOBBLE HV	RESET LIFETIME

All adjustments for beam generation and alignment are made in this menu and the following GUN-specific parameters are displayed on the monitor:

- Filament heating and emission current (actual and upper limit values)
- Warm-up time
- Filament start and number of operating hours
- Status codes
- High-voltage range

The following general operating parameters are also displayed:

- Magnification, magnification mode and imaging mode
- Illuminating aperture

GUN
PAR

Softkey GUN PAR

Used to activate the submenu GUN PAR

- Variable High voltage control (option)
 - Filament type
 - Gun conditioning
- (see section 3.5.1)

VARIABLE
H V

Softkey VARIABLE HV (option)

Used to activate the adjusted variable high voltage.

- The desired high-voltage value can be adjusted in the menu HV / FIL SELECT with activated or non-activated function.

- Softkey pushed:

- Key field highlighted.
- The high-voltage value adjusted in the submenu HV / FIL SELECT is effective and displayed in the main menu.

- Pushing the softkey again deactivates the function and activates the standard values.

< 60 KV >

Softkeys <60 KV > to <120 KV>

Used to select a high voltage.

- Softkey pushed: the selected key field is highlighted.

When the option VARIABLE HIGH VOLTAGE is activated, the selected kV value is a base value. Starting from this base value the high voltage is variable by max. \pm 15kV. With active step 120kV the high voltage is variable only towards lower values.

to

< 120 KV >

RETURN

Softkey RETURN

Used for return to the main menu

RECALL
GUN ALIGN

Softkey RECALL GUN ALIGN

Used to retrieve the values of FILAMENT PRECENTERING and BEAM ALIGNMENT from the hard disk.

FIL.
CURRENT

Softkey FIL. CURRENT

Used to adjust the filament heating current.

The current is adjusted separately for tungsten and LaB6 filaments. The filament is selected in the submenu GUN PAR.

- Softkey pushed: (key highlighted)

- Encoder CURRENT on the right control panel now has the function “adjust heating current”.
- Field FILAMENT CURRENT highlighted.

- Heating current adjusted with encoder CURRENT. (Current display in field FILAMENT CUR.)

- Softkey pushed again or exit from menu:

- Encoder CURRENT is set again to emission current control.

FIL.
PRECENT.

Softkey FIL. PRECENT.

Used to symmetrize the filament emission image.

Adjusting aid in the menu ADJUST ASSISTANCE !

- Softkey pushed: key field highlighted.
- Additional softkey STORE GUN ALIGN displayed.
- Emission image symmetrized in SPOT mode with underheated filament, with encoders X and Y in field ILLUMINATION.
- Adjustment stored on the hard disk with STORE GUN ALIGN.
- Function reset by pushing the softkey again or exit from the menu.
- Function deactivated, STORE GUN ALIGN disappears.

BEAM
ALIGN.

Softkey BEAM ALIGNM.

Used to align the condenser zoom system.

Adjusting aid in the menu ADJUST ASSISTANCE !

- Softkey pushed: key field highlighted.
- Additional softkey STORE GUN ALIGN displayed.
- Beam centered in diffraction, at 0.06mrad illuminating aperture, with IMAGE SHIFT.
- With double key ILL. APERTURE/SPOT SIZE illuminating aperture changed between 0.06mrad and 2.5mrad.
- Encoders X and Y adjusted in field ILLUMINATION so that the luminous spot lies exactly in the center of the fluorescent screen at 0.06mrad and 2.5mrad.
- Setting stored on the hard disk with STORE GUN ALIGN.
- Softkey pushed again or exit from menu:
- Function deactivated, STORE GUN ALIGN disappears.

STORE
GUN ALIGN

Softkey STORE GUN ALIGN

Displayed only when softkey FIL. PRECENT. or BEAM ALIGNM. is pushed.

The values adjusted by the aforementioned functions are stored on the hard disk.

Pushing the softkey activates display of the enquiry STORE GUN ALIGN.

- Answering with Y from the keyboard stores the settings
FILAMENT PRECENTERING and BEAM ALIGNMENT on the hard disk.

Answering with N from the keyboard or making no input within 10 seconds deactivates the enquiry menu.

WOBBLE
HV

Softkey WOBBLE HV

Used to activate the high-voltage wobbler. The filament DC voltage is then modulated at low-amplitude AC voltage.

The function supports the adjustment of the paraxial beam incidence on the specimen.

- High-contrast specimen feature in center of fluorescent screen.
- Softkey pushed.
- Function active: key field highlighted.
- Specimen movement minimized with encoders X and Y in field ILLUMINATION TILT.
- Deactivation: softkey WOBBLE HV pushed again.
- With exit from the menu without previous switch-off the function remains activated.

RESET
LIFETIME

Softkey RESET LIFETIME

Used to zero the operating hour counter for the selected filament.

Pushing the softkey displays the enquiry RESET LIFETIME.

- Answering with Y from the keyboard sets the LIFETIME display to 0 HOUR.
- Answering with N from the keyboard or making no input within 10 seconds deactivates the enquiry menu.

3.5.1

Menu GUN PAR

HV-SELECT DOWN	HV-SELECT UP	VARIABLE H V	HV-STEP DOWN	HV-STEP UP		H V DOWN	H V UP
<div style="border: 1px solid black; padding: 5px; display: inline-block;">G U N P A R A M E T E R</div>							
HIGH VOLTAGE :		120.000 kV		LIFE TIME :		0 HOURS	
HIGH VOLTAGE STEP :		10 U		P4 :		0E-0 hPa	
EMISSION CURRENT :		<1 µA					
FILAMENT		RESISTANCE(Ω)	MAX. CURRENT(A)	WARM UP SPEED(mA/s)			
-----		-----					
TYPE 1: TUNGSTEN		0.50	3.00	4000			
TYPE 2: TUNGSTEN		0.50	2.00	4000			
RETURN<	G U N CONDIT.		FILAMENT SELECT	EDIT TYPE 1	EDIT TYPE 2	CALCUL. FIL. DIST.	RESET LIFETIME

The following parameters are defined in this menu:

- High-voltage step
- Filament type (tungsten or LaB6)
- Amount and step width of variable high-voltage values (option).

Softkey HV-SELECT DOWN (option VARIABLE HV)

Used to reduce the variable high-voltage values by the selected HV step width. A reduction of max. 15kV off the base value is possible.

The variable high-voltage value is effective and displayed in the main menu only when the softkey VARIABLE HV is pushed.

Softkey HV-SELECT UP (option VARIABLE HV)

Used to increase the variable high-voltage value by the selected HV step width. An increase of max. 15kV off the base value is possible (exception: base value 120kV which must not be exceeded).

The variable high-voltage value is effective and displayed in the main menu only when the softkey VARIABLE HV is pushed.

HV-SELECT
DOWN

HV-SELECT
UP

VARIABLE
HV

Softkey VARIABLE HV (option)

Used to activate the adjusted variable high voltage.

- Softkey pushed: key field highlighted.
 - The selected high-voltage value is effective and displayed in the main menu.
- Softkey pushed again or other high-voltage step activated:
 - Variable high voltage deactivated.
 - Standard values reactivated.

HV-STEP
DOWN

Softkey HV-STEP DOWN (option VARIABLE HV)

Used to reduce the step width when adjusting the variable high voltage.

The step width is variable in 10V steps from 10V to 1 000V.

HV-STEP
UP

Softkey HV-STEP UP (option VARIABLE HV)

Used to increase the step width when adjusting the variable high voltage.

The step width is variable in 10V steps from 10V to 1 000V.

HV
DOWN

Softkey HV DOWN

Used to decrease the High voltage in steps (120 kV → 60 kV)

HV
UP

Softkey HV UP

Used to increase the High voltage in steps (60 kV → 120 kV)

RETURN

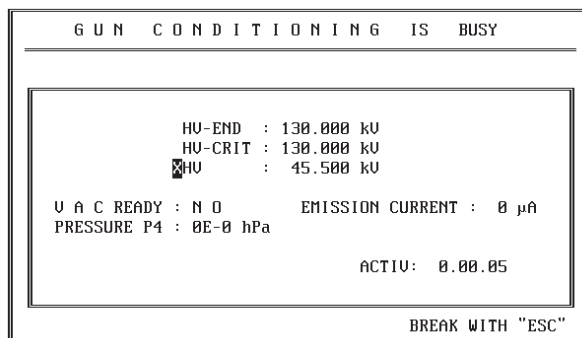
Softkey RETURN

Used for return to the menu GUN.

G U N
CONDIT.

Softkey GUN CONDIT.

Used to condition the gun especially after filament exchange.



FILAMENT
SELECT



EDIT
TYPE 1

and

EDIT
TYPE 2

- Softkey pushed enquiry is displayed.
 - If answered with Y GUN CONDIT. function is highlighted.
 - Gun conditioning starts. When finished monitoring window disappears automatically.
 - If answered with N, or no input is made within 10 seconds enquiry window disappears.

The gun condit. program formats the gun insulator by monitoring the vacuum and the leakage current. The program starts at 45 kV , and increases the HV in very fine steps. The programs stops the formation at 130 kV. Then the HV is reset to the preselected value.

Softkey FILAMENT SELECT

Used to change from filament type 1 to filament type 2.

The operating parameters for the selected filament are activated.

- Softkey pushed: the enquiry CATHODE SELECT is displayed.
 - With Y the change is made to the second actually non-active filament type.
 - With N the previous type remains adjusted.

No input will automatically provide for input termination 10 seconds after display of the enquiry.

CAUTION

with an LaB6 filament!

Warm-up speed and internal resistance influence the lifetime of the filament.

Softkeys EDIT TYPE 1 and EDIT TYPE 2

Used to change the operating parameters for filament type 1 or 2.

The fields CATHODE, RESISTANCE (Ω) (effective only with 24-step HV unit), MAX. CURRENT (A) for filament heating current and WARM UP TIME (mA/s), and the speed of filament heating are edited.

- Push softkey.
 - Field CATHODE
ENTER filament name from keyboard. 12 digits are allowed.
 - Field RESISTANCE (Ω)
for input of the internal resistance.
- From the keyboard enter values between 0.2 and 10 Ω for the internal resistance (3 digits, decimal point can be omitted).
Example: 50 oder 0.5 for 0.5 Ω .
- Terminate input with <ENTER>, otherwise automatic termination 10 seconds after input of the last character. If an invalid value is entered the flashing cursor asks for new input after pushing <ENTER>.
- This value is used only with a 24-step high-voltage unit.

Warning

The input of an internal resistance which does not coincide with the actual value of the filament will cause malfunctions which may destroy the filament.

Field MAX. CURRENT (A)

- From the keyboard enter values between 0.01 and 4A for the filament heating current (3 digits, decimal point can be omitted). Example: 300 or 3.0 for 3A.
- Terminate input with <ENTER>, otherwise automatic termination 10 seconds after input of the last character. If an invalid value is entered the flashing cursor asks for new input after pushing <ENTER>.

Field WARM UP TIME (mA/s)

- From the keyboard enter values from 1 to 4 000mA/s for warm-up time and end input with <ENTER>.
- If the key <ENTER> is not operated the input is automatically terminated 10 seconds after input of the last character. If an invalid value is entered the blinking cursor asks for new input after pushing <ENTER>.

Softkey CALCUL. FIL. DIST.

Used to start a measuring program to define the actual filament distance. The difference to the reference value is displayed by the menu.

The distance between filament and Wehnelt aperture influences the maximum obtainable emission current and brightness on the fluorescent screen.

CALCULATE FILAMENT DISTANCE is an auxiliary function which may be used to exactly adjust the distance between filament tip and front surface of Wehnelt aperture for measurement. The function is suitable only for tungsten hairpin filaments and high voltages between 80 and 120kV. It is important for applications which use the entire emission current range as far as the adjustable limit. Only for this application need the filament distance be exactly adjusted. For beam currents <math>< 3 \mu\text{A}</math> the filament heating can be used for continuous brightness adjustment. Köhler illumination guarantees homogeneous illumination of the image even with underheated filament.

Pushing the softkey starts a measuring program which, by current measurement, determines the actual filament distance and compares it with the reference value. The reference value of filament distance A is: $A = 0.20 \pm 0.025\text{mm}$. The difference to the reference value is displayed after measurement in the line CHANGE FIL. DISTANCE as deviation in [mm]. Coded washers of different thickness are available for adjustment.

Operation of the function CALCUL. FIL. DISTANCE

- Switch on high voltage and filament heating.
- Push softkey:
 - Enquiry CALCUL. FIL. DISTANCE is displayed.
 - If N is pushed or no input made within 10 seconds a reset is made to menu GUN.
 - Pushing Y continues the program.

CALCUL.
FIL. DIST.

- A second inquiry SET FIL. CURRENT TO 3.5 A is displayed.
- If N is pushed or no input made within 10 seconds a reset is made to the menu GUN.
- Pushing Y automatically sets the filament current to 3.5A for measurement, the emission current to step 12, and determines the distance. The original values are re-adjusted after measurement.

The determined difference is displayed in field CHANGE FIL. DISTANCE. -0.04mm means, for instance that the filament distance must be reduced 0.04mm by corresponding washers.

- If the value is positive the distance must be adjusted by adding washers. The distance should be adjusted exactly to within 0.02mm! Washers with thicknesses of 0.020mm, 0.050mm and 0.100mm are available.

RESET
LIFETIME

Softkey RESET LIFETIME

Used to zero the operating hour counter for the selected filament.

Pushing the softkey displays the enquiry RESET LIFETIME.

- Answering with Y from the keyboard sets the LIFETIME display to 0 HOUR.
- Answering with N from the keyboard or making no input within 10 seconds deactivates the enquiry menu.

3.6 Menu GONIOMETER

G O N P A R >	P O S S E R >	STORE POSIT.	EDIT COMMENT	AUTO STORE INC	AUTO REC. INC	RESET GON TILT	RESET POSITION
M A G : 2 0 0 0 0 x G O N I O M E T E R							
CURRENT SPECIMEN POSITION:				STORED SPECIMEN POSITION:			
X =	+6933	μm	X =	-0000	μm		
Y =	+6933	μm	Y =	-0000	μm		
Z =	+6933	μm	Z =	+0000	μm		
θ =	-82.0	$^{\circ}$	θ =	-00.0	$^{\circ}$		
MODE: < M > < IMAGE >				ADDRESS NO: 6			
ILLUM. ANGLE : 0.10 mrad				COMMENT: [REDACTED]			
EMISSION CUR. : <1 μA				NUMBER OF FRAMES: 10			
RETURN<	RECALL POSIT.	LAST ADDRESS	NEXT ADDRESS	EDIT ADDRESS	START POS. -SCAN	STOP POS. -SCAN	ADJUST EUC. AXIS

The menu is used to

- store, provide with comments and retrieve up to 99 goniometer positions
- reset the goniometer to mid-position and calibrate it to the eucentric axis
- activate the option POSITION SERIES for meander scanning of the specimen
- vary the speed of the tilt axis Θ and, if installed, the additional tilt axis Φ or the axis of rotation ε in 8 steps by the submenu GONIOMETER PARAMETERS.

G O N
P A R

Softkey GON PAR

Used to call the menu GONIOMETER PARAMETERS (see section 3.6.1).

The menu is used to adjust the travelling speed of the following goniometer axes:

- 1st tilt axis
- 2nd tilt axis with incorporated double tilt rod. Axis of rotation with incorporated tilt/rotation rod. The goniometer control recognizes automatically which motorized specimen rod is in use.

POS
SER

Softkey POS SER (option)

Used to call the menu POSITION SERIES (see section 3.6.2).

The menu is used to enter the parameters for image series such as

- edge points
- degree of overlap
- film format, etc.

STORE
POSIT.

Softkey STORE POSIT.

Used to store the present specimen position under the actual address.

To store successively several selectable positions, activate first the function AUTO STORE INC. Only the softkey STORE POSIT. need then be pushed for storage.

EDIT
COMMENT

Softkey EDIT COMMENT

Used to enter text for the displayed memory location.

- Softkey pushed: flashing cursor in the field COMMENT asks for input.
- ENTER text from the keyboard (16 characters).
- From the keyboard terminate input with <ENTER>.

If <ENTER> is not operated the input is automatically terminated 10 seconds after input of the last character.

AUTO
STORE INC

Softkey AUTO STORE INC

Used for automatic increase of memory address number by 1 after storage of a goniometer position.

Successively selectable positions are stored under successive addresses by pushing only the softkey RECALL POSIT.

- Softkey pushed:
 - Key field highlighted.
 - Automatic system activated.
- Softkey pushed again: automatic system deactivated.

AUTO
REC. INC

Softkey AUTO REC.INC

Used for automatic increase of memory address number by 1 after call of a stored goniometer position.

Several successively stored positions can be “keyed through” with the softkey RECALL POSIT. alone.

- Softkey pushed:
 - Key field highlighted.
 - Automatic system activated.
- Softkey pushed again: automatic system deactivated.

RESET
GON TILT

**Softkey RESET GON TILT**

Used to reset the goniometer tilt angle to zero degree.

SPECIAL NOTE:

If a special motorized specimen rod is connected with additional tilt axis Φ or axis of rotation ϵ the corresponding additional axis will also be reset to 0.

RESET
POSITION

Softkey RESET POSITION

Used for automatic reset of all goniometer axes to mid-position (except for optional rod axes Φ and ϵ).

RETURN

Softkey RETURN

Used for return to the main menu.

RECALL
POSIT.

Softkey RECALL POSIT.

Used to locate the displayed stored position.

To recall successively several successively stored positions activate first the function AUTO REC. INC. To change from one position to the next only the above softkey need be pushed.

LAST
ADDRESS

Softkey LAST ADDRESS

Pushing the softkey displays the position with the next lower memory location number in the field STORED SPECIMEN POSITION.

NEXT
ADDRESS

Softkey NEXT ADDRESS

Pushing the softkey displays the position with the next higher memory location number in the field STORED SPECIMEN POSITION.

EDIT
ADDRESS

Softkey EDIT ADDRESS

Used to display any stored position.

- Softkey pushed: in the field ADDRESS NO. the cursor asks for input.
- From the keyboard enter any number between 1 and 99 as memory location.
- From the keyboard terminate input with <ENTER>.

If <ENTER> is not operated the input is automatically terminated 10 seconds after input of the last character. If an invalid value is entered the cursor asks for new input after pushing <ENTER>.

The following softkeys can now be activated:

- STORE POSIT.: the data memory is overwritten by the actual position data.
- RECALL POSIT.: the displayed specimen position is activated.

START
POS.-SCAN

Softkey START POS.-SCAN

Used to start or continue the meander program (option).

STOP
POS.-SCAN

Softkey STOP POS.-SCAN

Used to interrupt the meander program (option).

ADJUST
EUC. AXIS

Softkey ADJUST EUC. AXIS

It causes the goniometer to swing between + and – 12° for adjustment of the eucentric axis.

- Softkey pushed:
 - Key field highlighted.
 - The goniometer swings.
- With calibrated objective lens (for calibration push key CALIBRATE in field FOCUS) minimize image shift with the goniometer Z shift.
- Softkey pushed again: goniometer stops at 0.

3.6.1

Menu GON PAR

		RECALL ADD AXIS				RESET GON TILT	RESET POSITION
MAG : 20000 x G O N P A R A M E T E R							
CURRENT SPECIMEN POSITION:							
X =	+6933	μm	SPEED :			1	
Y =	+6933	μm	SPEED :			1	
Z =	+6933	μm					
θ =	-82.0	°	SPEED :			0	
MODE: < M > < IMAGE >							
ILLUM. ANGLE : 0.10 mrad							
EMISSION CUR. : <1 μA							
RETURN<	AXIS SELECT	SPEED DOWN	SPEED U P				INIT AXIS

The menu is used to

- to display the actual position of all 4 (optionally 5) goniometer axes
- adjust the speed of rotation of the 1st tilt axis Θ and, if installed, the 2nd tilt axis Φ or the axis of rotation ϵ in 8 steps
- set the goniometer automatically to mid-position (activation status)
- automatically reset to zero the tilt axis Θ and, if installed, also the tilt axis Φ (option) or the additional axis of rotation ϵ (option).

RECALL
ADD AXIS

Softkey RECALL ADD AXIS

The function must be activated for selection of the additional 5th coordinate Φ or ϵ together with automatic relocation of stored goniometer positions.

The softkey is displayed only with either of the two motorized special specimen rods with one further tilt or rotation axis each. All 5 coordinates are always stored.

The key field is highlighted if the function is activated. The positioning accuracy is lower with the relocation of the 5th than with the other 4 coordinates because of the hysteresis in the specimen rod.

RESET
GON TILT

Softkey RESET GON TILT

Used to reset the goniometer tilt angle Θ to zero degree.

**SPECIAL NOTE:**

If a motorized special specimen rod with additional tilt axis Φ or axis of rotation ε is connected, the corresponding additional axis will also be reset to 0.

RESET
POSITION

Softkey RESET POSITION

Used for automatic reset of all goniometer axes to mid-position.
(Status as after EM 912 OMEGA start-up)

RETURN

Softkey RETURN

Used for return to the menu GONIOMETER.

AXIS
SELECT

Softkey AXIS SELECT (option)

Used to select the axis for which the softkeys SPEED DOWN and SPEED UP are effective.

The softkey is displayed only with either of the two motorized special specimen holders, each having one further tilt or rotation axis each.

- Softkey pushed: luminous bar in field SPEED changes from one SPEED display to the other. SPEED DOWN and SPEED UP softkeys are effective for the speed display with highlighted bar.

SPEED
DOWN

Softkey SPEED DOWN

Used to reduce the speed of rotation for the selected axis by one out of 8 steps.
The following step/speed assignment (angular degree/s) is valid for the axes:

	Axis X	Axis Y	Axis Θ	Axis Φ	Axis ε
SPEED 1	0.1	0.1	0.1	0.1	0.2
SPEED 8	1	1	1	1	2

SPEED
UP

Softkey SPEED UP

Used to increase the speed of rotation for the selected axis by one out of 8 steps.
The following step/speed assignment (angular degree/s) is valid for the axes:

Values as above.

3.6.2 Menu POSIT. SERIES (option)

DISP MATR>	REF.P1	REF.P2	REF.P3	REF.P4	CALCUL. MATRIX	STORE REF.Px	LOAD REF.Px
---------------	--------	--------	--------	--------	-------------------	-----------------	----------------

MAG : 4 0 0 0 x POSIT. SERIES

SPECIMEN POSITION:

X = +6933 μm
 Y = +6933 μm
 Z = +6933 μm
 θ = -82.0 °

OVERLAPPING: 3 %
 FILM SIZE X: 78 mm
 FILM SIZE Y: 78 mm
 DWELL TIME : 1 sec

AREA OF INT.
 P1 ← ← P4
 | |
 P2 → → P3

REF.P1 X = -0082 μm Y = +0029 μm
 REF.P2 X = -0048 μm Y = -0041 μm
 REF.P3 X = +0023 μm Y = -0007 μm
 REF.P4 X = -0010 μm Y = +0063 μm

MODE: < M > < IMAGE >
 ILLUM. ANGLE : 0.10 mrad
 EMISSION CUR.: < 1 μA

NUMBER OF FRAMES: 10

RETURN<	EDIT OVERLAP.	EDIT FILMS.X.	EDIT FILMS.Y.	EDIT DWELL T.	START POS. SCAN	STOP POS. SCAN	NEXT FRAME
---------	------------------	------------------	------------------	------------------	--------------------	-------------------	---------------

The menu is used to make the settings for image series. The user defines a square on the specimen which is scanned in a meander pattern. The number of steps depends on

- the film size and the adjusted magnification
- the desired overlap of the single frames
- the size of the observed specimen square.

After parameter input the image matrix is calculated with the softkey CALCUL. MATRIX. The matrix is then scanned automatically or in single steps with the softkey NEXT FRAME.

Softkey DISP MATR

Used to call the menu MATRIX.

The arrangement of the single frames of a matrix is schematically displayed by a graph. The position of the observed single frame of a matrix is optically set off.

Softkeys REF. P1 to REF. P4

Used to select the 4 corner points of the square on the specimen that is to be scanned.

IMPORTANT NOTE:

Observe direction of rotation. The correct position of the corner points is displayed on the monitor by AREA OF INTEREST.

DISP
MATR

REF. P1

to

REF. P4

CALCUL.
MATRIX

Softkey CALCUL. MATRIX

Used to calculate the position data and the number of single frames from the input data. The position is adjusted.

The matrix must be recalculated after each change of data.

STORE
REF. Px

Softkey STORE REF. Px

Used to store the individual reference positions.

LOAD
REF. Px

Softkey LOAD REF. Px

Used to load and then change the reference positions.

- Push softkey REF. Px (1 to 4).
- Push softkey LOAD REF. Px;
 - the positions of the selected reference points are displayed
 - enter goniometer position (change value)
- Push softkey STORE REF. Px (store new value).

RETURN

Softkey RETURN

Used for return to the menu GONIOMETER

EDIT
OVERLAP.

Softkey EDIT OVERLAP.

Used to enter the degree of overlap of the single frames.

- Softkey pushed: the cursor in the field OVERLAPPING asks for input.
- ENTER a value between 0 and 99 as overlap in percent.
- From the keyboard terminate input with <ENTER>. If <ENTER> is not operated the input is automatically terminated 10 seconds after input of the last character.

EDIT
FILMS.X.

Softkey EDIT FILMS. X.

Used to enter the scan format in the X direction.

- Softkey pushed: the cursor in the field FILM SIZE X asks for input.
- ENTER a value between 0 and 99 as film length X in mm:

Sheet-film camera	70mm
TV (CCD camera)	30mm
Scan on fluorescent screen	99mm
- From the keyboard terminate input with <ENTER>. If <ENTER> is not operated the input is automatically terminated 10 seconds after input of the last character.

EDIT
FILMS.Y.

Softkey EDIT FILMS. Y.

Used to enter the scan format in the Y direction.

- Softkey pushed: the cursor in the field FILM SIZE Y asks for input.
- ENTER a value between 0 and 99 as film length Y in mm:

Sheet-film camera	70mm
TV (CCD camera)	40mm
Scan on fluorescent screen	99mm
- From the keyboard terminate input with <ENTER>. If <ENTER> is not operated the input is automatically terminated 10 seconds after input of the last character.

EDIT
DWELL T.

Softkey EDIT DWELL T.

Used for input of the goniometer dwell time at each single frame position.

- Softkey pushed: the cursor in the field DWELL TIME asks for input.
- ENTER a value between 0 and 99 as dwell time in seconds.
- From the keyboard terminate input with <ENTER>. If <ENTER> is not operated the input is automatically terminated 10 seconds after input of the last character.

START
POS. SCAN

Softkey START POS. SCAN

Used to start the scanning program.

The previously defined specimen square is scanned in a meander pattern.

STOP
POS. SCAN

Softkey STOP POS. SCAN

Used to interrupt the scanning program.

The scanning program can be continued with the key START POS. SCAN.

Scanning of the image matrix in single steps can be made with the softkey NEXT FRAME.

NEXT
FRAME

Softkey NEXT FRAME

Used to scan the image matrix in single steps.

The number of the observed single frame is displayed in the field NUMBER OF FRAMES. The position of the single frame in the observed specimen square is schematically displayed by a graph after pushing the softkey DISP MATR.

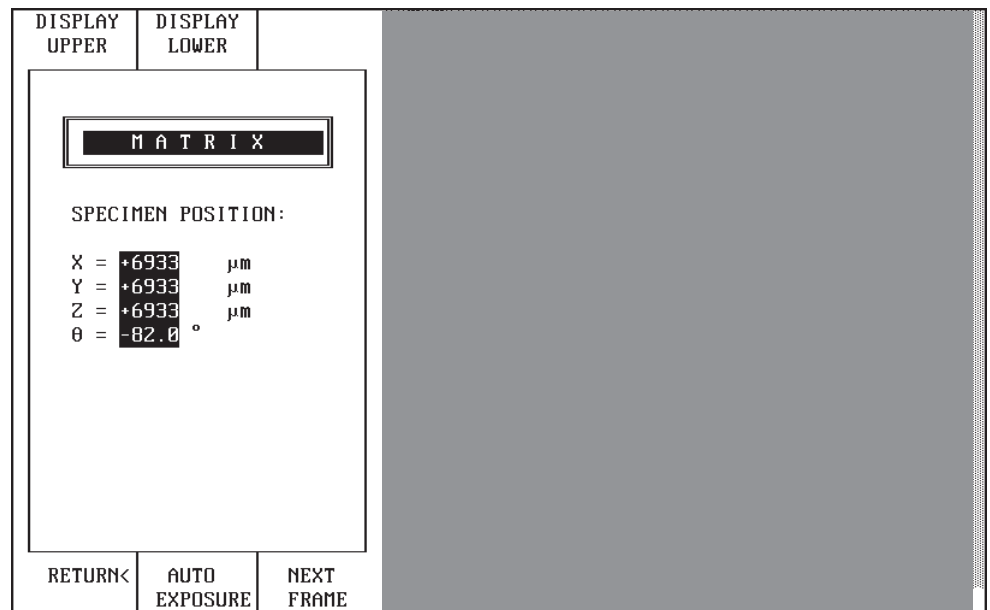
INIT.
AXIS

Softkey INIT. AXIS

Used to initialize the goniometer axes mechanically.

After this procedure the all axes are set to zero mechanically and electronically.

Menu MATRIX (for option POSITION SERIES)



In this menu the arrangement of the single frames of a series is schematically displayed by a graph. The position of the observed single frame of the series is optically set off.

Softkey UPPER

Used to display schematically arrangement and position of the single frames in the upper half of the observed specimen square.

The function is required to display extensive image series (max. number of single frames: 2500). Two sides of the monitor are required to display the specimen square. Change between the sides is made with the softkeys UPPER and LOWER.

Softkey LOWER

Used to display schematically arrangement and position of the single frames in the lower half of the observed specimen square.

The function is required to display extensive image series (max. number of single frames: 2500). Two sides of the monitor are required to display the specimen square. Change between the sides is made with the softkeys UPPER and LOWER.

Softkey RETURN

Used for return to the menu POSIT. SERIES.

UPPER

LOWER

RETURN

AUTO
EXPOSURE

Softkey AUTO EXPOSURE

Used for automatic photomontage. The exposure series starts with the actual frame and ends with film supply=0 or when the scan is completed.

NEXT
FRAME

Softkey NEXT FRAME

Used for stepwise scanning of the image matrix.

The position of the single frame in the observed specimen square is displayed on the monitor. For photomontages the key EXPOSURE must be pushed for exposure release after each image shift.

3.7 Menu CAMERA



SPECIAL NOTE:

Depending on which camera was selected (menu CAM SETTING) either the menu SHEET FILM CAMERA or the menu 35MM-CAMERA is displayed.

3.7.1 Menu CAMERA (sheet-film camera)

C A M S E T >	E X P S E R >	BEAM BLANKER	M I S MODE	M I S SELECT	EDIT USER/NO	EDIT FREE INP.	EDIT COMMENT
<p>M A G : 5 0 0 0 x SHEET FILM CAM.</p> <p>STATUS: OK</p> <p>FILM DATA: CZ 291297 M 5000<2.90µm> Nr. 7411 U120- 0 -82.0°</p> <p>COMMENT:</p> <p>FILM SUPPLY: 02 EXPOSURE METER: CAMERA COLLECTOR FILM DENSITY B: 3.6 e1/µm² EXPOSURE TIME : AUTOMATIC sec DATA DENSITY B: 15 FIXED 2.4 sec</p>							
RETURN<	FIX.TIME DOWN	FIX.TIME UP	EDIT FIX.TIME	MULTI EXPOSURE	EXP.TIME MODE	DENS A/ DENS B	D F TILT

The menu is used for the settings for operation and control of the sheet-film camera. Displayed are:

- Magnification
- Camera status
- Imprinted data block and comments for printer
- Film supply, film and data density
- Exposure mode
- Selected exposure meter, measured and fixed exposure time.



Softkey CAM SET

Used to call the menu CAM SETTING (see section 3.7.3).

The menu is used to make the base settings for the sheet-film camera.

EXP
SER

Softkey EXP SER (option)

Used to call the menu EXP. SERIES (see section 3.7.5).

Different types of exposure series with the corresponding settings are possible:

- Series with variable focus
- Series with variable exposure time
- Series with variable tilt angle.

In operating mode “Serie” (series) the key EXPOSURE on the left control panel is ineffective. Operation of the key will activate an error code.

BEAM
BLANKER

Softkey BEAM BLANKER

The function is used to deflect the beam before it reaches the specimen, which reduces exposure to irradiation.

- Softkey pushed:
 - Key field highlighted.
 - Display in the main menu “BEAM BLANKER ON”.
 - If the softkey is pushed again the beam is redeflected to the specimen.

MIS
MODE

Softkey MIS MODE

Used for manual selection of the 5 differently sized AIS apertures (MIS stands for Manual Illumination Selection).

The Köhler illumination system allows the use of the condenser aperture as selected-area aperture. MIS mode may also be used together with MDF mode for narrow limitation of the irradiated area.

- Softkey pushed:
 - Key field highlighted, MIS mode activated.
 - The additional softkey MIS SELECT is displayed.
 - The condenser aperture which defines the luminous field may now be selected with the softkey MIS SELECT independent of the magnification.

MIS
SELECT

Softkey MIS SELECT

Used to select the next AIS aperture in MIS mode.

This softkey is displayed only in MIS mode.

EDIT
USER/NO

Softkey EDIT USER/NO

Used to enter user identification and negative number in the data field.

- Softkey pushed: the flashing cursor in the 1st position of the right data field asks for input.
- ENTER user identification (2 characters except for ä, ö and ü).
- From the keyboard terminate input with <ENTER>. The cursor jumps to the 3rd position of the right data field:
- ENTER the negative number from the keyboard (max. 6 numbers) and push <ENTER>. If <ENTER> is not operated the input is automatically terminated 10 seconds after input of the last character. If an invalid value is entered, the flashing cursor requests new input after pushing <ENTER>.

EDIT
FREE INP.

Softkey EDIT FREE INP.

Used for free text input for the data field on the negative.

- Softkey pushed: in the lower line of the left field for data imprint on the film the flashing cursor asks for input.
- Write text. Max. 16 characters are allowed, but no modified vowels.
- From the keyboard terminate input with <ENTER>.

If <ENTER> is not operated the input is automatically terminated 10 sec after input of the last character.

EDIT
COMMENT

Softkey EDIT COMMENT

Used for input of comments for data printout. (A printer and an interface card (option) are required for data printout.)

- Softkey pushed: in the upper line of the field COMMENT the flashing cursor asks for input.
- ENTER comments from the keyboard. Any input of max. two lines of max. 60 characters each is allowed, but no modified vowels.
- From the keyboard terminate input with <ENTER>.

If <ENTER> is not operated the input is automatically terminated 10 sec after input of the last character.

RETURN

Softkey RETURN

Used for return to the main menu.

FIX. TIME
DOWN

Softkey FIX. TIME DOWN

Used to shorten a given exposure time.

- Softkey pushed: the displayed fixed exposure time is shortened by the factor 1.4 every time the key is pushed.

FIX. TIME
UP

Softkey FIX. TIME UP

Used to extend a given exposure time.

- Softkey pushed: the displayed fixed exposure time is extended by the factor 1.4 every time the key is pushed.

EDIT
FIX. TIME

Softkey EDIT FIX. TIME

Used to enter a given exposure time.

- Softkey pushed: in the field FIXED the flashing cursor asks for input.
- From the keyboard enter a value between 0.2 and 300 seconds as exposure time.
- From the keyboard terminate input with <ENTER>.

If <ENTER> is not operated the input is automatically terminated 10 sec after input of the last character. If invalid values are entered the cursor asks for a new input after pushing <ENTER>.

MULTI
EXPOSURE

Softkey MULTI EXPOSURE

Used to switch to multiple exposure.

- Softkey pushed: key field highlighted, operating mode “multiple exposure” activated.
- Key EXPOSURE on left control panel pushed:
 - The plate is advanced to exposure position.
 - Release of first exposure, no return.
- Key EXPOSURE pushed again: next exposure of the same plate at the same exposure time.
- Softkey MULTI EXPOSURE pushed: multiple exposure deactivated, plate returned.

EXP. TIME
MODE

Softkey EXP. TIME MODE

Used to select the preset exposure time.

- AUTOMATIC: The exposure time is measured.
- FIXED: The exposure time complies with a preset value.
- Softkey pushed: luminous bar jumps from AUTOMATIC to FIXED or vice versa.

DENS A/
DENS B

Softkey DENS A / DENS B

Used to select the film density stored in data sets A and B.

- Softkey pushed: display FILM DENSITY / DATA DENSITY changes between data sets A and B. The film densities for A and B are entered in the menu CAM SETTING.

DF
TILT

Softkey DF TILT

Used to change to darkfield mode and switch the encoders ILLUMINATION X, Y to the beam tilt setting.

- Softkey pushed.
 - Key field highlighted.
 - Switch-over to darkfield mode. The beam tilt offset of the data set is activated, which was selected in the DF menu.
- Correction of beam tilt by encoder ILLUMINATION X, Y.

3.7.2 Menu 35MM CAMERA (option)

C A M S E T >	E X P S E R >	BEAM BLANKER	M I S MODE	M I S SELECT	EDIT USER/NO	EDIT FREE INP.	EDIT COMMENT
<p>M A G : 5 0 0 0 x 3 5 M M C A M E R A</p> <p>STATUS: OK</p> <p>FILM DATA: CZ 1 291297 M 5000<2.90µm> Nr. 7411 U120- 0 -82.0°</p> <p>COMMENT:</p> <p>FILM SUPPLY: 20 FILM DENSITY : 2 e1/µm² EXPOSURE TIME : AUTOMATIC sec FIXED 38.2 sec</p>							
RETURN<	FIX.TIME DOWN	FIX.TIME UP	EDIT FIX EXP	MULTI EXPOSURE	EXP.TIME MODE	EDIT DENSITY	D F TILT

The menu is used for the settings for operation and control of the 35mm camera.

Displayed are:

- Magnification
- Camera status
- Comments for printer
- Film supply, film and data densities
- Exposure mode
- Selected exposure meter, measured and fixed exposure time.

Softkey CAM SET

Used to call the menu CAM SETTING (see section 3.7.4).

The menu is used to make the base settings for the 35mm camera.

Softkey EXP SER (option)

Used to call the menu EXP. SERIES (see section 3.7.5).

Different types of exposure series can be selected and the corresponding settings made, namely:

- Series with variable focus
- Series with variable exposure time
- Series with variable tilt angle.

The key EXPOSURE on the left control panel is functionless in operating mode "Serie" (series). Operating the key will activate an error code.



BEAM
BLANKER

Softkey BEAM BLANKER

Used to activate the electron beam blanker.

In this operating mode the electron beam blanker is activated before the specimen area of interest to reduce exposure to irradiation.

BEAM BLANKER ON is displayed in the main menu.

- Softkey pushed.
 - Key field highlighted.
 - Beam blanker on.
- Softkey pushed again: beam blanker off.

MIS
MODE

Softkey MIS MODE

Used for manual selection of the AIS steps (MIS stands for Manual Illumination Selection).

- Softkey pushed:
 - Key field highlighted, MIS mode activated. Adjustment of AIS mode is impossible.
 - Additional softkey MIS SELECT is displayed.
 - The condenser aperture defining the luminous field can now be selected with the softkey MIS SELECT independent of the magnification.

MIS
SELECT

Softkey MIS SELECT

Used to select the next AIS step. This softkey is displayed only in MIS mode.

EDIT
USER/NO

Softkey EDIT USER/NO

Used to enter user identification and negative number in the data field.

- Softkey pushed: the flashing cursor in the 1st position of the right data field asks for input.
- ENTER user identification (2 characters except for ä, ö and ü).
- From the keyboard terminate input with <ENTER>. The cursor jumps to the 3rd position of the right data field:
- ENTER the negative number from the keyboard (max. 6 numbers) and push <ENTER>. If <ENTER> is not operated the input is automatically terminated 10 seconds after input of the last character. If an invalid value is entered, the flashing cursor requests new input after pushing <ENTER>.

EDIT
FREE INP.

Softkey EDIT FREE INP.

Used for free text input for the data field on the negative.

- Softkey pushed: the flashing cursor in the lower line of the left field for the data imprint on the film asks for input.
- Write text. Max. 16 characters are allowed, but no modified vowels.

EDIT
COMMENT

- From the keyboard terminate input with <ENTER>.

If <ENTER> is not operated the input is automatically terminated 10 seconds after input of the last character.

Softkey EDIT COMMENT

Used to enter comments for the data printout. (Besides the printer an optional printer interface is required for data printout.)

- Softkey pushed: the flashing cursor in the upper line of the field COMMENT asks for input.
- ENTER comments from the keyboard. Any input of max. 2 lines of max. 60 characters is allowed, but no modified vowels.
- From the keyboard terminate input with <ENTER>. If <ENTER> is not operated the input is automatically terminated 10 seconds after input of the last character.

RETURN

Softkey RETURN

Used for return to the main menu.

FIX. TIME
DOWN

Softkey FIX. TIME DOWN

Used to shorten the given exposure time.

- Softkey pushed:
 - The displayed fixed exposure time is shortened by the factor 1.4 every time the key is pushed.

FIX. TIME
UP

Softkey FIX. TIME UP

Used to extend the given exposure time.

- Softkey pushed:
 - The displayed fixed exposure time is extended by the factor 1.4 every time the key is pushed.

EDIT
FIX EXP

Softkey EDIT FIX EXP

Used for input of the given exposure time.

- Softkey pushed: the flashing cursor in the field EXPOSURE TIME FIXED asks for input.
- From the keyboard enter a value between 0.2 and 300 seconds as exposure time.
- From the keyboard terminate input with <ENTER>.

If <ENTER> is not operated the input is automatically terminated 10 seconds after input of the last character. If invalid values are input, the cursor asks for new input if <ENTER> is pushed again.

MULTI
EXPOSURE**Softkey MULTI EXPOSURE**

Used to change to multiple exposure.

- Softkey pushed: key field highlighted and operating mode “multiple exposure” activated.
- Key EXPOSURE on left control panel pushed: release of first exposure, no advance of negative.
- Key EXPOSURE pushed again: next exposure of the same negative at the same exposure time.
- Softkey MULTI EXPOSURE pushed: multiple exposure deactivated, advance of negative.

EXP. TIME
MODE**Softkey EXP. TIME MODE**

Used to select the given exposure time.

- AUTOMATIC: The exposure time is measured.
- FIXED: The exposure time is preselected.
- Softkey pushed: luminous bar jumps from AUTOMATIC to FIXED and vice versa.

EDIT
DENSITY**Softkey EDIT DENSITY**

Used for density adjustment for 35mm film.

- Softkey pushed: the flashing cursor in the line of the field FILM DENSITY asks for input.
- From the keyboard enter a value between 1 and 999 as film density.
- From the keyboard terminate input with <ENTER>.

If <ENTER> is not operated the input is automatically terminated 10 seconds after input of the last character.

DF
TILT**Softkey DF TILT**

Used to change to darkfield mode and switch the encoders ILLUMINATION X, Y to beam tilt setting.

- Softkey pushed:
 - Key field highlighted.
 - Change to darkfield mode. The beam tilt offset of the data set is activated, which is selected in the DF menu.
- Correction of beam tilt with encoder ILLUMINATION X, Y.

3.7.3

Menu CAM SETTING (sheet-film camera)

PL / 35 MM			EDIT FILM SUP.	EDIT USER/NO	CLEAR CAM. FILE	AUTO PRINT	AUTO FILE
MAG : 20000 x <div style="float: right; border: 1px solid black; padding: 2px;">CAM SETTING</div> <div style="text-align: center; border: 1px solid black; padding: 2px;">SHEET FILM CAM.</div> USE THICK PLATE HOLDER Σ EXPOSURE: 000000 FILM DATA: <div style="float: right; border: 1px solid black; padding: 2px;">EZ 011297 M 20000<0.73µm> Liposomes frozen U120- 0 0nm</div> FILM DENSITY A: 1.5 e1/µm ² DATA DENSITY A: 1.6 FILM DENSITY B: 3.6 e1/µm ² DATA DENSITY B: 1.5 FILM SUPPLY: 02 EXPOSURE METER: CAMERA COLLECTOR DATE: 01.12.1997 TIME: 20.16.23							
RETURN<	SELECT I/δf/θ	EDIT DENS A	EDIT DENS B		SELECT EXP.METER	EDIT TIME	EDIT DATE

The menu is used for the base settings for the sheet-film camera. The following parameters are displayed on the monitor:

- Adjusted magnification
- Film holder in use (thin or universal film holder)
- Sum of all counted exposures
- Film supply
- Density (A and B) for film and data field imprints
- Data field imprinted on the negative
- Time and date.

In addition it is possible to change to the CAM SETTING menu of the 35mm camera.

Softkey PL/35MM

Used to switch between the menus PL CAMERA and 35MM CAMERA.

The softkey is displayed only with activated optional 35mm camera. The settings for operation and control of the sheet-film camera are carried out in the menu PL-CAMERA.

Softkey EDIT FILM SUP.

Used for input of the number of loaded films. The counter counts each exposure and sets the FILM SUPPLY display to the actual film supply after each exposure.

- Softkey pushed:
 - Flashing cursor in the field FILM SUPPLY asks for input.
- ENTER film supply (values between 1 and 50) and push key <ENTER>. If <ENTER> is not operated the input is automatically terminated 10 seconds after input of the last character. If an invalid value is entered a new input is requested after pushing the key <ENTER>.

PL /
35 MM

EDIT
FILM SUP.

EDIT
USER/NO

Softkey EDIT USER/NO

Used for input of user identification and negative number in the data field.

- Softkey pushed: the flashing cursor in the 1st position of the right data field asks for input.
- ENTER user identification (2 characters except for ä, ö and ü).
- From the keyboard terminate input with <ENTER>. The cursor jumps to the 3rd position of the right data field.
- ENTER negative number from the keyboard (max. 6 numbers) and push key <ENTER>. If <ENTER> is not operated the input is automatically terminated 10 seconds after input of the last character. If an invalid value is entered the flashing cursor asks for a new input after pushing the key <ENTER>.

CLEAR
CAM. FILE

Softkey CLEAR CAM. FILE

Used to clear on the hard disk the CAMERA.TXT file for automatic storage of max. 100 data sets.

- After each film exchange and before executing this function the CAMERA.TXT file must be saved on a floppy disk.
- Softkey pushed: the enquiry "CLEAR CAM. FILE" is displayed.
 - Answering with Y from the keyboard clears the CAMERA. TXT file on the hard disk.
 - Answering with the N or making no input within 10 seconds deactivates the enquiry menu.

AUTO
PRINT

Softkey AUTO PRINT (option)

Used for activation of automatic data field printout after each exposure.

The key field is highlighted if the function is activated.

AUTO
FILE

Softkey AUTO FILE

Used for automatic documentation of the camera data field on the hard disk. Max. 100 data sets may be stored in an intermediate memory. Output comes from file CAMERA.TXT in the directory C:\EM\TEXT. Copy the file CAMERA.TXT to a floppy disk (drive A) after each film exchange using the function STORE RESULTS in the START menu, to prevent data from being lost by automatic overwriting after the hundredth exposure.

- Softkey pushed:
 - Key field highlighted.
 - After each exposure text is automatically copied on hard disk.

Example of a printout on next page.

RETURN

Softkey RETURN

Used for return to the menu PL-CAMERA.

Example of a data record (sheet film camera)

```

EXPOSURE NO PLAN : 45
DATE/TIME       : 03.02.1993 / 17.10.05
USER           : WP
FREE INPUT     : Ceramics. step 1

HIGH VOLTAGE   : 120 kV
BEAM CURRENT   : 3 µA
FILAMENT      : LaB6
MAGNIFICATION M : 12500
O.LENS CURRENT : 4314 mA + 35 mA
ILLUM.APERTURE : 1.0 mrad
BEAM TILT     : X: 0 Y: 10
ENERGY LOSS   : 0.0 eV
DEFOCUS      : 0 nm
FOCUS STEP    : 60 nm

VACUUM       : P4: 7E-8 hPa

COORDINATES  : X: +0453µm, Y: -0177µm, Z: +0037µm
TILT ANGLE   : Θ: -00.0
HOLDER ROT/TILT :

DENSITY      : 0.8 el/µm2
EXPOSURE METER : CAMERA COLLECTOR
COLL. CURRENT : 24E-12
EXPOSURE TIME : 2.4 s
COMMENT      : THE COMPLETE DATA RECORD MAY BE AUTOMATICALLY
              PRINTED, STORED IN ASCII ON HARD DISK, OR
              TRANSFERRED TO EXTERNAL COMPUTERS ON FLOPPY
              DISK.

```

SELECT
I/δF/Θ

Softkey SELECT I/δF/Θ

Used to select the parameter to be imprinted on the negative.

Available are:

- I = Current for set energy loss ΔE
- δF = Defocus adjusted by the computer
- Θ = Tilt angle of specimen.

See also section 1.2.8.

EDIT
DENS A

Softkey EDIT DENS A (for sheet-film camera only!)

Used for input of density A for image and data exposure. Two data sets A and B are available.

- Softkey pushed: the cursor in data field FILM DENSITY A asks for input.
- From the keyboard enter a density value between 0.1 and $99\text{el}/\mu\text{m}^2$ and push <ENTER>. The cursor jumps to field DATA DENSITY A and asks for input.
- ENTER a density value between 1 and 99, push key <ENTER>. If <ENTER> is not operated within 10 sec the input is automatically terminated after input of the last character. If an invalid value is entered a new input is requested after pushing <ENTER>.

EDIT
DENS B

Softkey EDIT DENS B (for sheet-film camera only!)

Used for input of density B for image and data exposure. Two data sets A and B are available.

- Softkey pushed: the cursor in data film FILM DENSITY B asks for input.
- From the keyboard enter a density value between 0.1 and $99\text{eI}/\mu\text{m}^2$ and push <ENTER>. The cursor jumps to field DATA DENSITY B and asks for input.
- ENTER a density value between 1 and 99, and push <ENTER>. If <ENTER> is not operated within 10 sec the input is automatically terminated after input of the last character. If an invalid value is entered a new input is requested after pushing <ENTER>.

SELECT
EXP. METER

Softkey SELECT EXP. METER

Used to select the electron collector for exposure measurement. Available are the focusing fluorescent screen or the camera collector below the film plane (integral measurement over the entire sheet-film format).

- Softkey pushed:
 - The collector SMALL SREEN or CAMERA COLLECTOR is alternatively adjusted and displayed in the field EXPOSURE METER.

EDIT
TIME

Softkey EDIT TIME

Used for input of a new time.

- Softkey pushed: the flashing cursor in the field TIME asks for input.
- ENTER for the time a value between 00.00.00 and 23.59.59.
- From the keyboard terminate input with <ENTER>. If <ENTER> is not operated the input is automatically terminated 10 seconds after input of the last character. If an invalid value is entered the old time is displayed if this menu is recalled.

EDIT
DATE

Softkey EDIT DATE

Used for input of a new date.

- Softkey pushed: the flashing cursor in the field TIME asks for input.
- ENTER for the date a value between 01.01.00 and 31.12.99.
- From the keyboard terminate input with <ENTER>. If <ENTER> is not operated the input is automatically terminated 10 seconds after input of the last character. If an invalid value is entered the old date is displayed if the menu is recalled.

3.7.4 Menu CAM SETTING (35mm camera) (option)

PL / 35 MM			EDIT FILM SUP.	EDIT USER/NO	CLEAR CAM. FILE	AUTO PRINT	AUTO FILE
MAG : 20000 x			CAM SETTING 35MM - CAMERA				
Σ EXPOSURE: 000000							
FILM DATA:			EZ 1 011297 M 20000<0.73µm> Liposomes frozen U120- 0 0nm				
FILM SUPPLY: 20			EXPOSURE METER: CAMERA COLLECTOR DATE: 01.12.1997 TIME: 20.20.31				
RETURN<	SELECT I/δf/θ				SELECT EXP.METER	EDIT TIME	EDIT DATE

The menu is used for base settings for the 35mm camera. The following parameters are displayed on the monitor:

- Adjusted magnification
- Sum of all counted exposures
- Film supply
- Data field imprinted on the negative
- Time and date.

It is also possible to change to the CAM SETTING menu of the sheet-film (PL) camera.

PL/
35 MM

Softkey PL/35MM

Used to change between the menus 35MM and PL-CAMERA.

The settings for operation and control of the 35mm camera are made in the 35MM CAMERA menu.

EDIT
FILM SUP.

Softkey EDIT FILM SUP.

Used for input of the number of loaded films. The counter counts each exposure and sets the FILM SUPPLY display to the actual film supply after each exposure.

- Softkey pushed:
 - The flashing cursor in the field FILM SUPPLY asks for an input.
- ENTER a value between 1 and 50 for the film supply and push <ENTER>. If <ENTER> is not operated the input is automatically terminated 10 seconds after input of the last character. If an invalid value is entered, a new input is requested after pushing <ENTER>.

Version 3.20

EDIT
USER/NO

Softkey EDIT USER/NO

Used to enter user identification and negative number in the data field.

- Softkey pushed: the flashing cursor in the 1st position of the right data field asks for input.
- ENTER user identification (2 characters except for ä, ö and ü).
- From the keyboard terminate input with <ENTER>. The cursor jumps to the 3rd position of the right data field:
- ENTER the negative number from the keyboard (max. 6 numbers) and push <ENTER>. If <ENTER> is not operated the input is automatically terminated 10 seconds after input of the last character. If an invalid value is entered, the flashing cursor requests new input after pushing <ENTER>.

CLEAR
CAM. FILE

Softkey CLEAR CAM. FILE

Used to clear on the hard disk the CAMERA.TXT file for automatic storage of max. 100 data sets.

- After each film exchange and before executing this function, save the CAMERA.TXT file on floppy disk.
- Softkey pushed: the enquiry "CLEAR CAM. FILE" is displayed.
 - Answering with Y from the keyboard clears the CAMERA.TXT file on the hard disk.
 - Answering with N or making no input within 10 seconds deactivates the enquiry menu.

AUTO
PRINT

Softkey AUTO PRINT (option)

Used to activate after each exposure the automatic data field printout.

The key field is highlighted if the function is activated.

**SPECIAL NOTE:**

Example of a data field printout see description of the menu PL-CAMERA.

AUTO
FILE

Softkey AUTO FILE (option)

Used for automatic documentation of the camera data field on the hard disk. Max. 100 data sets can be stored in the intermediate memory. Output from file CAMERA.TXT in directory C:\EM\TEXT. After each film exchange the file CAMERA.TXT must be copied on a floppy disk using the function STORE RESULTS in the START menu to prevent data from being lost by automatic overwriting after the hundredth exposure.

- Softkey pushed:
 - Key field highlighted.
 - After each exposure texts are automatically copied on the hard disk.

**SPECIAL NOTE:**

The contents of the data field file correspond to the data record (see description of menu PL-CAMERA).

RETURN

Softkey RETURN

Used for return to the menu 35MM-CAMERA.

SELECT
I/δF/Θ

Softkey SELECT I/δF/Θ

Used to select the parameter to be imprinted on the negative.

Available are:

I = Current at selected energy loss ΔE

δF = Defocus adjusted by the computer

Θ = Tilt angle of specimen.

See also section 1.2.8.

SELECT
EXP. METER

Softkey SELECT EXP. METER

Used to select the electron collector for exposure measurement. Available is the focusing fluorescent screen or the camera collector below the film plane (integral measurement over the entire film format).

- Softkey pushed:
 - The collector SMALL SCREEN or CAMERA COLLECTOR is alternatively adjusted and displayed in the field EXPOSURE METER.

EDIT
TIME

Softkey EDIT TIME

Used for input of a new time.

- Softkey pushed: the flashing cursor in the display field TIME asks for input.
- ENTER a value between 00.00.00 and 23.59.59 for the time.
- From the keyboard terminate input with <ENTER>. If <ENTER> is not operated the input is automatically terminated 10 seconds after input of the last character. If an invalid value is entered the old time is displayed if the menu is recalled.

EDIT
DATE

Softkey EDIT DATE

Used for input of a new date.

- Softkey pushed: the flashing cursor in the display field TIME asks for input.
- ENTER a value between 01.01.00 and 31.12.99 for the date.
- From the keyboard terminate input with <ENTER>. If <ENTER> is not operated the input is automatically terminated 10 seconds after input of the last character. If an invalid value is entered the old date is displayed if the menu is recalled.

3.7.5 Menu EXPOS. SERIES (option)

FOCUS SERIES	EXP. TIME SERIES		δE SERIES	GON TILT SERIES			
EXPOS. SERIES							
CURRENT VALUE:		0	nm				
NUMBER OF EXP.:		9		EXPOSED:		0	
START POINT:		-4000	nm	INPUT WILL BE CORRECTED IN 4 nm STEPS			
STEP:		1000	nm	EXP. TIME:		sec	
				FIX TIME:		2.4	sec
				FILM SUPPLY:		20	
RETURN<	EDIT NUMBER	EDIT START P.	EDIT STEPWIDTH	CHECK SERIES	START EXP. SER.	STOP EXP. SER.	NEXT

The following exposure series can be selected in this menu and the corresponding settings made:

- Series with variable focus
- Series with variable exposure time
- Series with variable tilt angle
- Series with varied energy loss

In this operating mode the key EXPOSURE on the left control panel is functionless. If it is pushed by mistake, the error code 20 is displayed on the monitor: operating mode "exposure series" activated.

FOCUS
SERIES

Softkey FOCUS SERIES

Used to preselect an exposure series with variable focus.

- Softkey pushed.
 - Key field highlighted.
 - Start of focus series with softkey START EXP. SER.
- Softkey pushed again: function deactivated.

EXP. TIME
SERIES

Softkey EXP. TIME SERIES

Used to preselect exposure series with variable exposure time.

- Softkey pushed.
 - Key field highlighted.
 - Start of exposure time series with softkey START EXP. SER.
- Softkey pushed again: function deactivated.

ΔE
SERIES

Softkey ΔE SERIES

Used to preselect exposure series with varied energy loss ΔE.

- Softkey pushed:
 - Key field highlighted.
 - Exposure series with varied ΔE may be started with START EXP. SER..
- Softkey pushed again: function deactivated.

GON TILT
SERIES

Softkey GON TILT SERIES

Used to preselect exposure series with variable goniometer tilt angle.

- Softkey pushed.
 - Key field highlighted.
 - Start of tilt angle series with softkey START EXP. SER.
- Softkey pushed again: function deactivated.

RETURN

Softkey RETURN

Used for return to the previously selected camera menu.

EDIT
NUMBER

Softkey EDIT NUMBER

Used for input of the number of exposures of a series.

- Softkey pushed: cursor in field NUMBER OF EXP. asks for input.
- From the keyboard enter a value between 1 and 50 for the number of exposures.
- From the keyboard terminate the input with <ENTER>. If <ENTER> is not operated the input is automatically terminated 10 seconds after input of the last character. If invalid values are entered the cursor asks for new input after pushing <ENTER>.

EDIT
START P.

Softkey EDIT START P.

Used for input of the initial value of a series.

- Softkey pushed: the cursor in the field START POINT asks for input.
- ENTER the start value from the keyboard. Permissible values:
 - Focus: integers between plus and minus 8000nm. The input is rounded up to a value divisible by 4.
 - Exposure time series: between 0.2 and 100 seconds. ENTER values of less than 1 second with decimal point.
 - Tilt angle series: between plus and minus 45° (integers).
- From the keyboard terminate input with <ENTER>. Invalid input: request for new input.

EDIT
STEPWIDTH

Softkey EDIT STEPWIDTH

Used for input of the step width of the varied parameter.

The cursor in the field STEP asks for input.

- ENTER start value from the keyboard. Permissible values:
 - Focus series: between 4 and + 1000 nm, integers (rounded up to a value divisible by 4).
 - Exposure time series: between 0.2 and 100 seconds. ENTER values of less than 1 second with decimal point.
 - Tilt angle series: enter a value between 1 and 45° (integers).
- From the keyboard terminate input with <ENTER>. Invalid input: request for new input.

CHECK
SERIES

Softkey CHECK SERIES

Used to control the series without exposure release.

The softkey is displayed only if an exposure series was selected.

- Softkey pushed:
 - Key field highlighted.
 - Control function activated.
- Softkey pushed again: control function deactivated.

START
EXP. SER.

Softkey START EXP. SER.

Used to start the exposure series.

The softkey is displayed only if an exposure series was selected.

STOP
EXP. SER.

Softkey STOP EXP. SER.

Used to stop the exposure series.

With the softkey NEXT the exposure series is continued stepwise.

The softkey is displayed only if an exposure series was selected.

NEXT

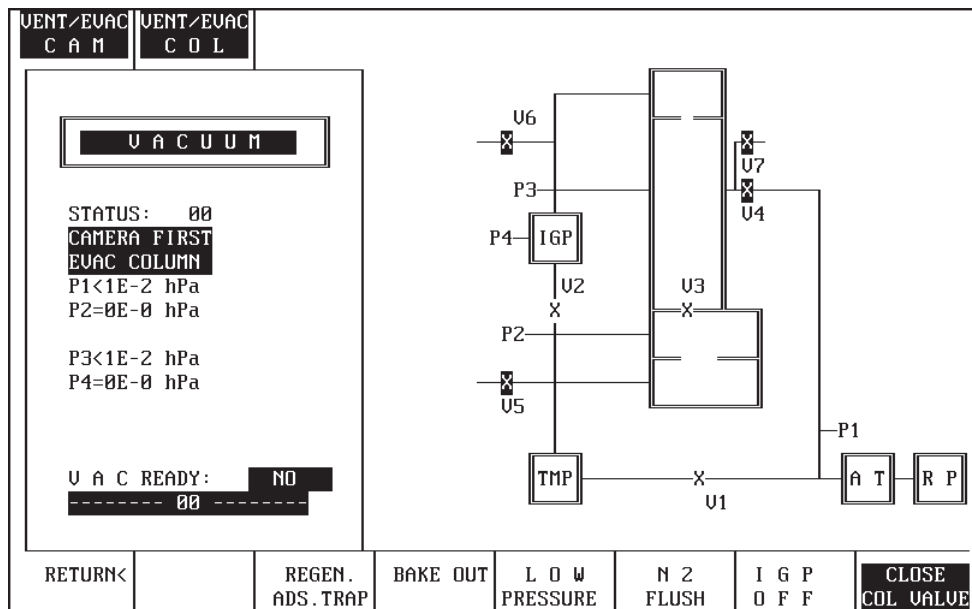
Softkey NEXT

Stepwise continuation of the exposure series after STOP.

The softkey is displayed only if an exposure series was selected.

3.8 Menu VACUUM

3.8.1 Standard vacuum system



Used to display the operating status of the vacuum system and to operate the system. The symbols of valves and pumps are highlighted if these are closed.

The following parameters and messages are displayed:

- Valve settings
- Pressure in prevacuum line (P1)
- Vacuum in camera chamber (P2)
- Prevacuum in specimen chamber (P3)
- High vacuum in specimen chamber (P4)
- Status codes which are also output to the LCD for the vacuum system in the left control panel.

VENT/EVAC
CAM

Softkey VENT/EVAC CAM

Used for ventilation or evacuation of the camera and viewing head chamber. Softkey equivalent to the same key on the left control panel.

- Softkey pushed. The enquiry VENT/EVAC CAM is displayed.
- Pushing Y on the keyboard ventilates the camera chamber.
- When N is pushed or no input made within 10 seconds the enquiry menu disappears.

When the camera chamber has been ventilated:

- Push softkey again.
- The enquiry menu is displayed again.
- Pushing Y evacuates the camera chamber.

VENT/EVAC
COL

Softkey VENT/EVAC COL

Used to ventilate or evacuate the specimen chamber. The softkey is equivalent to the same key on the left control panel.

- Softkey pushed: the enquiry VENT/EVAC COL is displayed.
- Pushing Y on the keyboard ventilates the specimen chamber
- When N is pushed or no input made within 10 seconds the enquiry menu disappears.

When the specimen chamber has been ventilated:

- Push softkey again.
- The enquiry menu is displayed.
- When Y is pushed the specimen chamber is evacuated again.

RETURN

Softkey RETURN

Used for return to the main menu.

REGEN.
ADS. TRAP

Softkey REGEN. ADS. TRAP

Used to start the regeneration program for the adsorption trap (option) .

Only for regeneration of the adsorption trap !

- Softkey pushed: key field highlighted. The regeneration program is started after instrument switch-off. The rotary pump continues running and is stopped after approx. 3 hours.

BAKE OUT

Softkey BAKE OUT (option)

Used to bake out the column.

Bakeout supports the vacuum system in pumping down residual gas molecules which have deposited in the high vacuum, especially on the surfaces of the specimen chamber.

The column is heated when the water cooling is switched off. The cooling water then circulates through a bypass line.

- Push softkey after vacuum system start-up (pumpdown).

LOW
PRESURE

Softkey LOW PRESSURE

Used to avoid any switch off of the IGP because of excellent vacuum.

Recommended for cryo operation.

N2
FLUSH

Softkey N2 FLUSH (option)

Used to ventilate the airlock chamber with dried nitrogen gas.

The function is required only for cryo transfer using the OXFORD cryo transfer system.

IGP
OFF

Softkey IGP OFF

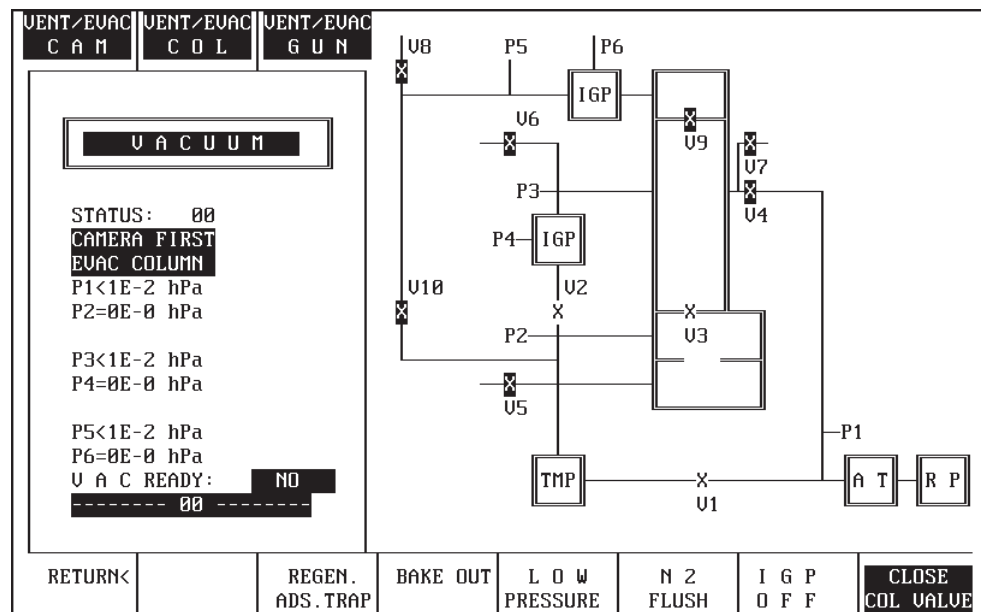
Used to switch off the column IGP. The TMP takes over the evacuation of the column. Recommended after cryo sessions.

CLOSE
COL. VALVE

Softkey CLOSE COL. VALVE

Used to close the V3 valve manually.

3.8.2 Vacuum system with option "2nd ion getter pump"



Used to obtain an overview of the operating status of the vacuum system with the option "2nd ion getter pump" and to operate the option. The symbols of valves and pumps are highlighted if these are closed.

The following parameters and messages are displayed:

- Valve settings
- Pressure in prevacuum line (P1)
- Vacuum in camera chamber (P2)
- Prevacuum in specimen chamber (P3)
- High vacuum in specimen chamber (P4)
- Pressure in prevacuum line (P5)
- High vacuum in filament chamber (P6)
- Status messages which are also output to the vacuum system LCD on the left control panel.

VENT/EVAC
CAM

Softkey VENT/EVAC CAM

Used to ventilate or evacuate the camera and viewing head chambers. Softkey equivalent to the same key on the left control panel.

- Softkey pushed. The enquiry VENT/EVAC CAM is displayed.
- Pushing Y on the keyboard ventilates the camera chamber.
- When N is pushed or no input made within 10 seconds the enquiry menu disappears.

When the camera chamber has been ventilated:

- Push softkey again.
- The enquiry menu is displayed again.
- Pushing Y evacuates the camera chamber.

VENT/EVAC
COL

Softkey VENT/EVAC COL

Used to ventilate or evacuate the specimen chamber. The softkey is equivalent to the same key on the left control panel.

- Softkey pushed: the enquiry VENT/EVAC COL is displayed.
- Pushing the Y key on the keyboard ventilates the specimen chamber.
- When N is pushed or no input made within 10 seconds the enquiry menu disappears.

When the specimen chamber has been ventilated:

- Push softkey again.
- The enquiry menu is displayed.
- When Y is pushed the specimen chamber is again evacuated.

VENT/EVAC
GUN

Softkey VENT/EVAC GUN

Used to ventilate or evacuate the filament chamber. The softkey is equivalent to the same key on the left control panel.

- Softkey pushed: the enquiry VENT/EVAC GUN is displayed.
- Pushing Y on the keyboard ventilates the filament chamber.
- When N is pushed or no input made within 10 seconds the enquiry menu disappears.

When the filament chamber has been ventilated:

- Push softkey again.
- The enquiry menu is displayed.
- When Y is pushed the specimen chamber is again evacuated.

RETURN

Softkey RETURN

Used to return to the main menu.

REGEN.
ADS. TRAP

Softkey REGEN. ADS. TRAP

Used to start the regeneration program for the adsorption trap (option) .
Only for regeneration of the adsorption trap !

- Softkey pushed: key field highlighted. The regeneration program is started after instrument switch-off. The rotary pump continues running and is stopped after approx. 3 hours.

BAKE OUT

Softkey BAKEOUT (option)

Used to bake out the column.

Bakeout supports the vacuum system in pumping down residual gas molecules deposited in the high vacuum, especially on the surfaces of the specimen chamber.

The column is heated when the water cooling is switched off. The cooling water will then circulate through a bypass line.

- Push softkey after vacuum system start-up (pumpdown).

LOW
PRESSURE

Softkey LOW PRESSURE

Used to avoid any switch off of the IGP because of excellent vacuum.
Recommended for cryo operation.

Softkey N2 FLUSH (option)

Used to ventilate the airlock chamber with dried nitrogen gas.

The function is required only for cryo transfer using the OXFORD cryo transfer system.

CLOSE
COL. VALVE

Softkey CLOSE COL. VALVE

Used to close or open the column valve (V3) and the gun valve (V9) simultaneously.

**SPECIAL NOTE:**

After operation of this function the high voltage is switched off automatically. The filament heating remains on. The high voltage can be switched on again after the gun valve was opened with this button (safety protection for the gun valve).

3.9 Menu δE

δE P A R >	S E R E E L S >	SPEC. MAG DOWN	SPEC. MAG UP	ZOOM FINE	EDIT $\delta E 1$	EDIT $\delta E 2$	TOGGLE FREQUENCY
M A G : <input type="text" value="6 3 0 0"/> x <input style="border: 1px solid black;" type="text" value=" "/> δE							
δE <input type="text" value="0.0"/> eU							
δE -STEP : <input type="text" value="10.0"/> eU							
DISPERSION : <input type="text" value="1.0"/> $\mu\text{m}/\text{eU}$							
MODE: < M > < IMAGE >							
ILLUM. ANGLE : <input type="text" value="0.10"/> mrad							
EMISSION CUR.: <input type="text" value="<1"/> μA							
SPECTRUM MAG : <input type="text" value="315"/> x							
$\delta E 1$: <input type="text" value="100"/> eU $\delta E 2$: <input type="text" value="300"/> eU							
RETURN<	δE DOWN	δE UP	TOGGLE δE -STEP	TOGGLE $\delta E 1/\delta E 2$		PEELS MODE	H C I/ 0 eU

All parameters for operation and control of energy loss imaging and energy loss spectroscopy are adjustable by the menu δE and its submenus.

Displayed are:

- Actual energy loss
- δE increment
- Slit position and corresponding slit width
- High-voltage-dependent spectrometer dispersion
- Spectrum magnification
- 2 δE values to toggle

δE
PAR

Softkey δE PAR

Used to call the menu δE PARAMETERS

For operation see section 3.9.1

Presettings for energy loss imagings are adjustable by this submenu.

S E R
E E L S

Softkey SER EELS

Used to call the menu SER EELS.

For operation see section 3.9.2

SPEC. MAG
DOWN

and

SPEC. MAG
UP

ZOOM
FINE

EDIT
 $\delta E1$

and

EDIT
 $\delta E1$

TOGGLE
FREQUENCY

δE
DOWN

and

δE
UP

Softkeys SPEC. MAG DOWN and SPEC. MAG UP

Used to decrease or increase the spectrum magnification by one step (factor 1.25). The function is active only in activated SPEC mode.

- Every time the softkey is pushed the spectrum magnification is decreased or increased by the factor 1.25.

The softkey SPEC. MAG FINE allows finer magnification adjustment.

Range: 40x to 315x.

Softkey ZOOM FINE

Used to vary the spectrum magnification factor in finer steps.

- Softkey pushed:
 - Key field highlighted
- With the softkeys SPEC. MAG DOWN and SPEC. MAG UP the spectrum magnification is varied in fine steps.

Softkeys EDIT $\delta E1$ and $\delta E2$

Used to put in two energy loss values for toggling. The toggle function is started with TOGGLE $\delta E1/\delta E2$.

This function is available in IMAGE mode and in SPECTRUM mode.

Softkey TOGGLE FREQUENCY

Used to change the speed between the display of the two energy losses. Three different frequencies can be selected by pushing the softkey.

Softkeys δE DOWN and δE UP

Used to decrease or increase the δE value by the adjusted δE increment.

- Softkey pushed:
 - The δE value is decreased or increased.
 - The adjusted δE value is displayed in field δE .

TOGGLE
 δE -STEP

Softkey TOGGLE δE -STEP

Used to select fix δE increment values. The following values are available:

- 1 eV
- 5 eV
- 10 eV

TOGGLE
 $\delta E1/\delta E2$

Softkey TOGGLE $\delta E1/\delta E2$

Used to activate the toggle function.

- Softkey pushed: The $\delta E1$ and $\delta E2$ values are displayed in the δE window alternately controlled by the toggle frequency.

PEELS
MODE

Softkey PEELS MODE

Used to expand the spectrum perpendicular to the energy dispersive direction. The amount of expansion can be adjusted with the encoder in the spectrometer operation field on the left panel.

HCI/
0 eV

Softkey HCI / 0 eV

Used to toggle between the HIGH CONTRAST IMAGE and the ZERO LOSS IMAGE. For each change the softkey has to be pushed. The actual energy loss is displayed in the δE window (250 eV or 0 eV).

3.9.1

Menu δE PARAMETERS

ECO OFFS. MODE	ECO OFFS. ADJ.	PEELS MODE			δE CAL. DOWN	δE CAL. UP	
MAG : 6300 x		δE P A R A M E T E R					
δE 0.0 eV		δE -CALIBRATION FACTOR 0.91997					
δE -STEP : 10.0 eV		ECO - OFFSET X : 0					
		ECO - OFFSET Y : 0					
		$\delta E1$: 100 eV					
		$\delta E2$: 300 eV					
MODE: < M > < IMAGE >							
ILLUM. ANGLE : 0.10 mrad							
EMISSION CUR. : < 1 μA							
SPECTRUM MAG : 250 x		<< USE IMAGE KNOBS >>					
RETURN<	δE -STEP DOWN	δE -STEP UP	TOGGLE δE -STEP	TOGGLE $\delta E1/\delta E2$			

The menu is used to enter presettings for energy loss imaging and energy loss spectroscopy.

The following values can be entered:

- ECO offset adjustment
- Fine adjustment of the δE increment
- δE calibration factor
- PEELS mode to adapt the dynamic range to the SSCCD camera
- Toggle function for the δE increment

Softkey ECO OFFS. MODE

Function will be used for future applications.

Softkey ECO OFFS. ADJ.

Function will be used for future applications.

ECO
OFFS. MODE

ECO
OFFS. ADJ.

δE CAL.
DOWN

and

δE CAL.
UP

RETURN

δE -STEP
DOWN

and

δE -STEP
UP

TOGGLE
 δE -STEP

TOGGLE
 $\delta E1/\delta E2$

Softkeys δE CAL. DOWN and δE CAL. UP

Used to decrease or increase the factor for δE calibration.

- Set energy loss δE to 0.
- Shift ZERO LOSS image to index point (knob (35)) using SPEC (key (37)) and SHIFT (key (39)).
Any offset at right angles to the spectrum can be eliminated by adjustment with IMAGE and SHIFT.
- Adjust the δE value to the reference value of a known element edge:
e.g: C = 284 eV
 AL = 1560eV
- Calibrate edge to the index point:
 - If the edge is too high, hold down softkey δE CAL. DOWN until the edge is on the index point.
 - If the edge is too low, hold down softkey δE CAL. UP until the edge is on the index point.

Softkey RETURN

Used to return to the menu δE

Softkeys δE STEP DOWN

Used to adjust the δE increment in 0.2 eV steps.

The actual increment value is displayed in the window δE - STEP.

Softkey TOGGLE δE -STEP

Used to select fix δE increment values. The following values are available:

- 1 eV
- 5 eV
- 10 eV

Softkey TOGGLE $\delta E1/\delta E2$

Used to activate the toggle function.

- Softkey pushed: The $\delta E1$ and $\delta E2$ values are displayed in the δE window alternately controlled by the toggle frequency.

3.9.2

Menu SER EELS

CAGE / PMT	DWELLTIME DOWN	DWELLTIME UP	PMT-GAIN DOWN	PMT-GAIN UP	TIME CONSTANT	RESET PMT-OVERL	RESET δE
<p>MAG : 6 3 0 0 x S E R E E L S</p> <p>δE 2 0 8.0 eV ELECTRON DETECTOR</p> <p>δE-STEP : 1.0 eV DETECTOR : PMT</p> <p>DWELL TIME : 250 msec TIME CONSTANT : 0.3 sec</p> <p>δE-SCAN START : 200 eV PMT VOLTAGE : 0 U</p> <p>δE-SCAN STOP : 500 eV MIN. -- PMT-GAIN -- MAX.</p> <p>DISPERSION : 1.0 $\mu m/eV$</p> <p>MODE: < M > < IMAGE ></p> <p>ILLUM. ANGLE : 0.10 mrad</p> <p>EMISSION CUR.: <1 μA</p> <p>SPECTRUM MAG : 315 x</p>							
RETURN<	δE -STEP DOWN	δE -STEP UP	EDIT δE - START	EDIT δE - STOP	START δE -SCAN	STOP δE -SCAN	SCAN INTERRUPT

The menu is used to enter all parameter and presets for energy loss spectroscopy in the serial mode. This menu is only displayed, if the Serial Eels Detector is installed.

Softkey CAGE/PMT

Used to select the detector for signal measurement.

Available are:

- CAGE for Faraday cage
- PMT for photomultiplier tube

- Change between CAGE and PMT every time the softkey is pushed.

Softkeys DWELL TIME DOWN and DWELL TIME UP

Used to adjust the dwell time for each δE step for the δE scan.

Range: 10 to 1000ms.

The image (IMAGE) or spectrum (SPEC) produced by the scan is displayed for the dwell time. When the dwell time is over the energy loss is increased by the δE step and the produced image/spectrum displayed.

- Every time the softkey is pushed the value is decreased or increased by 1ms. When the softkey is held down the dwell time changes in fast scroll.

CAGE/
PMT

DWELLTIME
DOWN

and

DWELLTIME
UP

PMT-GAIN
DOWN

and

PMT-GAIN
UP

TIME
CONSTANT

RESET
PMT-OVERL.

RESET
 δE

RETURN

δE -STEP
DOWN

and

δE -STEP
UP

Softkeys PMT-GAIN DOWN and PMT-GAIN UP

Used to increase or decrease the operating voltage (gain) of the PMT in 10V increments.

Range: 250 to 800V

The adjusted value is displayed. A cursor displays the voltage status on a bar (0 to 100%).

Bar: MIN. -- PMT-GAIN -- MAX.

Softkey TIME CONSTANT

Used to adjust the time constant (damping) of the PMT (option).

Four time constants are available for adjustment to the selected δE scanning speed:

- 0.01s
- 0.1s
- 0.3s
- 1.0s

- The next time constant is adjusted every time the softkey is pushed.

Softkey RESET PMT-OVERL.

Used to reactivate PMT high voltage: the PMT high voltage is automatically switched off when the anode current exceeds the limit 3 μA .

Softkey RESET δE

Used to reset the δE value to zero.

- Softkey pushed: 0.0eV displayed in field δE .

Softkey RETURN

Used to return to the main menu.

Softkeys δE -STEP DOWN and δE -STEP UP

Used to decrease or increase the adjusted δE step in 0.2eV increments.

δE scans are carried out using the adjusted increment. Start and end values of the energy loss adjustment are given by the δE menu using the keys EDIT δE -START and EDIT δE -STOP.

- Every time the softkey is pushed the value in the field δE -STEP is decreased or increased by 0.2eV. When the softkey is held down the increment changes in fast scroll.

EDIT
 δE -START

Softkey EDIT δE START

Used to enter the starting energy loss value δE for the δE scan.

- Softkey pushed: cursor in field δE -SCAN START asks for input.
- Enter initial value for δE scan (max. range 0 - 2 500eV).
- Take over value by pushing <ENTER> on the keyboard.
If <ENTER> is not operated the entry is terminated 10 seconds after input of the last character.

EDIT
 δE -STOP

Softkey EDIT δE -STOP

Used to enter the upper energy loss value δE for the δE scan.

- Softkey pushed: cursor in field δE -SCAN STOP asks for input.
- Enter upper value for δE scan (max. range 0 — 2 500eV).
- Take over value by pushing <ENTER> on the keyboard. If <ENTER> is not operated the entry is terminated 10 seconds after input of the last character.

START
 δE -SCAN

Softkey START δE -SCAN

Used to start the δE scan.

The specimen is imaged step by step starting with the adjusted initial energy loss δE at the given δE increments and ending with the upper adjusted energy loss. The produced image (IMAGE) or spectrum (SPEC) is imaged for the adjusted dwell time.

The softkey SCAN INTERRUPT is displayed which may be used to interrupt a scan.

STOP
 δE -SCAN

Softkey STOP δE -SCAN

Used to stop the δE scan.

When restarting the scan will start again at the adjusted initial energy loss.

**SPECIAL NOTE:**

A scan can be interrupted using SCAN INTERRUPT.

SCAN
INTERRUPT

Softkey SCAN INTERRUPT

Used to interrupt the δE scan.

When the key START δE -SCAN is pushed again, the scan is continued at the energy loss value of the previous interruption.

The softkey is displayed only if the δE scan has been started using the key START δE -SCAN.

3.10 Menu IMAGE (option)

CONST. BRIGHTN.	BRIGHTN. FINE	Z O O M FINE			CAMERA SHUTTER	SEL. CCD SHUTTER	SHUTTER ON/OFF
M A G : 4 0 0 0 x I M A G E U T I L I T I E S							
DOSE-RATE: -NOT-CAL e1/nm ² s							
DETECTOR SHUTTER : EXT. BEAM B L A N K E R							
DEFOCUS: 0 nm							
MODE: < M > < IMAGE >							
SPOT SIZE : 10 nm							
EMISSION CUR. : <1 μA							
RETURN<	DISPLAY DEFOCUS	O V E R - V I E W	Z O O M D O W N	Z O O M U P	M D F MODE	B E A M BLANKER	CALIBRATE DOSE RATE

This menu is used for further illuminating and imaging modes.

The following modes are available:

- Constant brightness and brightness fine
- Overview with zoom up and down function
- Micro dose focusing and dose rate calibration

Different shutters can be selected for the operation of the SSCCD camera.

Softkey CONST. BRIGHTNESS

Used to activate the brightness adjustment with magnification change. The illuminating aperture is automatically readjusted with each magnification change so that the image brightness is constant independent of the magnification.

Increase in magnification means increasing exposure of the specimen to the electron beam!

Softkey BRIGHTNESS FINE

Used to activate an optional function for fine adjustment of variable image brightness which is in excess of the standard control by the zoom condenser.

CONST.
BRIGHTN.

BRIGHTN.
FINE

ZOOM
FINE

Softkey ZOOM FINE

Used to activate the ZOOM FINE function. It can be used in spectrum and in image mode, provided the overview mode is active.

The image mag. and the spectrum mag. can be demagnified up to 10 times.

CAMERA
SHUTTER

Softkey CAMERA SHUTTER

Used to activate the camera shutter manually.

SEL.. CCD
SHUTTER

Softkey SEL. CCD SHUTTER

Used to select the different shutters for the SSCCD camera. The following shutters are available:

- No shutter: no stop of the electron beam at all. This function is necessary to operate the remote interface without any conflicts.
- Beam blanker: the electron beam is deflected above the specimen. This mode is used for specimens which have to be exposed to a defined dose.
- Camera shutter: the electron beam is blanked by the mechanical camera shutter. The specimen is still irradiated. This shutter is selected for high resolution with the SSCCD camera. The shutter should not be closed for longer than 5 min.
- Fast PS shutter: the deflecting system below the specimen is active. The specimen is irradiated continuously. The shortest exposure time is 200 ms. The post specimen shutters are used for samples which are sensitive to temperature changes.
- Slow PS shutter: as above; the shortest exposure time is 1 s.

SHUTTER
ON/OFF

Softkey SHUTTER ON/OFF

The selected shutter can be activated manually.

DISPLAY
DEFOCUS

Softkey DISPLAY DEFOCUS

Used to display the manual defocus in the menu and on the data block of the negative.

After activating the function DISPLAY DEFOCUS the focus display is set to zero, but the objective lens current is not changed. If the focus is then changed with the focus knob, the actual defocus is displayed on the menu and on the negative.

The previous defocus program is automatically deactivated.

When the objective lens is calibrated, the function DISPLAY DEFOCUS is deactivated and the previous defocus program is active again. This also will happen, if the function DISPLAY DEFOCUS is switched off manually.

This function is also available in the FOCUS PAR menu and in the MAIN menu.

OVER
VIEW

Softkey OVERVIEW

Used to activate the function ZOOM UP and ZOOM DOWN.

This function allows the adaptation of the magnification of the SSCCD camera to the magnification on the viewing screen.

ZOOM
DOWN

Softkeys ZOOM DOWN and ZOOM UP

Used to zoom down and up the final image by a factor of 10.

The demagnification factor for each step is ≈ 2 . If the magnification was 5.000x, when the OVERVIEW mode was activated, the zoom range is within 500x to 5.000x.

and

ZOOM
UP

With the ZOOM FINE function the magnification can be zoomed down and up within this range continuously.

MDF
MODE

Softkey MDF MODE

Used to activate the Micro Dose Focusing system.

Presettings are done in the MDF menu (to call in the PARAMETER menu)

For operation see chapter 5.3

BEAM
BLANKER

Softkey BEAM BLANKER

Used to activate the beam blanker.

CALIBRATE
DOSE RATE

Softkey CALIBRATE DOSE RATE

Used to start the calibration program.

The calibration of the brightness allows to expose the specimen to the beam with a predefined dose.

The current is measured at each illumination angle and stored as a dose rate value. The dose rate is displayed in the IMAGE and in the MDF menu.

For operation see 5.3.

4

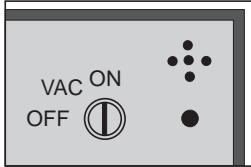
Microscope Operation

Table of contents

4	Microscope Operation	
4.1	EM system turn- ON	4-3
4.2	High-voltage selection	4-6
4.3	Basic settings after turn-ON	4-7
4.3.1	Insertion of condenser aperture	4-7
4.3.2	Spectrometer adjustment	4-7
4.3.3	Adjustment of illumination system	4-9
4.3.4	Compensation of SPOT astigmatism	4-11
4.3.5	Beam Alignment	4-12
4.3.6	Adjustment of the eucentric plane	4-13
4.3.7	Adjustment of beam incidence	4-14
4.3.8	Centration of objective lens aperture	4-15
4.3.9	Compensation of imaging astigmatism	4-15
4.4	Microscope settings	4-19
4.4.1	Emission current	4-19
4.4.2	Filament current	4-19
4.4.3	Image brightness	4-20
4.4.4	AIS	4-22
4.4.5	Magnification selection	4-23
4.4.6	Diffraction length selection	4-24
4.5	Microscopy	4-25
4.5.1	Specimen exchange	4-25
4.5.2	Specimen lock-in/out	4-27
4.5.3	Change between specimens	4-29
4.5.4	Use of the goniometer	4-31
4.5.5	Settings before screening	4-32
4.5.6	Low magnifications (LOW MAG = LM)	4-33
4.5.7	Systematic screening	4-36
4.5.8	Storage and location of specimen positions	4-37
4.5.9	Further goniometer settings from the menu	4-38
4.5.10	Eucentric tilt	4-39
4.5.11	Adjustment of Gaussian focus	4-40
4.5.12	Focus and defocus parameters	4-43
4.6	Viewing binocular adjustment	4-49

4.7	ESI imaging modes	4-50
4.7.1	Elastic imaging	4-50
4.7.2	Contrast tuning of thick specimens	4-51
4.7.3	Electron-spectroscopic imaging of thin specimens	4-52
4.7.4	Element-spectroscopic imaging	4-53
4.8	Brightfield / darkfield imaging	4-54
4.8.1	Brightfield imaging	4-54
4.8.2	Darkfield imaging	4-56
4.9	Diffraction	4-58
4.9.1	Selected-area diffraction with AIS apertures in M mode	4-59
4.9.2	Microbeam diffraction (Nanoprobe)	4-61
4.9.3	Convergent Beam Electron Diffraction (CBED)	4-62
4.9.4	Low-angle diffraction	4-64
4.10	Photography	4-65
4.10.1	Single exposures	4-65
4.10.2	Camera adjustment	4-66
4.10.3	Operation of sheet-film camera	4-69
4.10.3.1	Ventilation and pumpdown of camera chamber	4-69
4.10.3.2	Loading and removing films (general)	4-69
4.10.3.3	Adapting the sheet-film camera to the cassette type.	4-70
4.10.3.4	Loading cassettes and sheet-film camera	4-70
4.10.3.5	Removal of exposed sheet film (unloading the camera)	4-72
4.15.3.6	Sheet-film transport outside the camera	4-72
4.15.3.7	Desiccator	4-72
4.11	Backup messages	4-73
4.12	Storage of user data	4-74
4.12.1	Storage on hard disk	4-74
4.12.2	Storage on floppy	4-75
4.13	Loading user data	4-75
4.13.1	Loading user data from a floppy disk	4-75
4.13.2	Loading user data from hard disk	4-76
4.14	EM system turn-OFF	4-77
4.15	Status messages	4-78
4.15.1	Status messages of vacuum system	4-78
4.15.2	Error messages on EL display	4-83

4.1 EM system turn- ON



Gettin g the system ready

- **Turn key switch over VAC to ON.**
 - The vacuum system is activated for normal operation.
 - Host computer switched on.
 - DOS operating system, LEO 912 program and user data are loaded from the LEO 912 OMEGA hard disk.
 - Monitor display: LOADING SYSTEM DATA SET

If the following message window appears, you may quit and follow the advice later.

!! IT IS TIME TO BACKUP ALL DATA !!
ON A FLOPPY DISKETTE

!! CHECK THE AIR FILTER !!
IN THE POWER SUPPLY

PRESS ANY KEY TO CONTINUE

- **Confirmation with any key on the keyboard.**
 - The START menu is displayed on the control monitor.
 - Ready signal of the host computer by display of START menu.

CREATE DATA DISK	BACKUP ALL	STORE USER.DTA	STORE RESULTS	LIST HISTORY	DIR *.DTA	FORMAT DISK A:	
<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="border: 1px solid black; padding: 5px;"> <p style="text-align: center; margin: 0;">LEO912 SIMULATE</p> <p style="margin: 0;">VERSION : 912, U3.20β4</p> <p style="margin: 0;">REV. : 11-11-1997</p> <p style="margin: 0;">COPYRIGHT 1995-1997 LEO GmbH</p> <p style="margin: 0;">SERIAL NUMBER : 1000</p> <p style="margin: 0;">ALL RIGHTS RESERVED</p> </div> <div style="font-size: 2em; font-weight: bold; text-align: center;"> <p>LEO 912</p> <p>OMEGA</p> </div> </div>							
S T A R T		RECALL USER.DTA		EXIT TO DOS		D S A POWER	SERVICE DISABLED

Version 3.20

**SPECIAL NOTE:**

The host computer is ready for operation earlier than the vacuum system. Ready signal generally after approx. 2 minutes, if the vacuum system was in standby.

DSA
POWER

- **Switch on power supply of Scanning Attachment (option)**

by pushing soft key DSA POWER of the START menu (displayed only with installed attachment).

START

- **Call main menu.**

Push softkey START of START menu.

The most relevant operating parameters are displayed by the main menu:

- Illumination mode
- Imaging mode
- Magnification
- Illuminating angle or size of luminous spot
- High voltage
- Focus step size
- Defocus value
- Goniometer coordinates (X, Y, Z and Θ)
- Exposure time and film supply

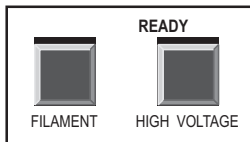
P A R >	G U N >	G O N >	C A M >	U A C >	δ E >	I M A G E >	E X I T <
MODE: < M > < I M A G E >				SPECIMEN POSITION:			
M A G : 6 3 0 0 x				X = +6 9 3 3 μ m		Y = +6 9 3 3 μ m	
ILLUM. MODE: < T E M > < B F >				Z = +6 9 3 3 μ m		θ = -8 2.0 °	
ILLUM. ANGLE : 0.10 mrad							
HIGH VOLTAGE: 120.00 kV							
EMISSION CUR.: <1 μ A							
δ E: 0 eV							
FOCUS STEP: 120 nm				EXP. TIME: sec			
DEFOCUS: 0 nm				FIX TIME: 38.2 sec			
				FILM SUPPLY: 20			
M / L M MODE		BEAM BLANKER		D F MODE		A I S MODE	
				M D F MODE		DISPLAY DEFOCUS	
						D S A	



Special note:

The host computer automatically sets the operating parameters as used before system turn-off.

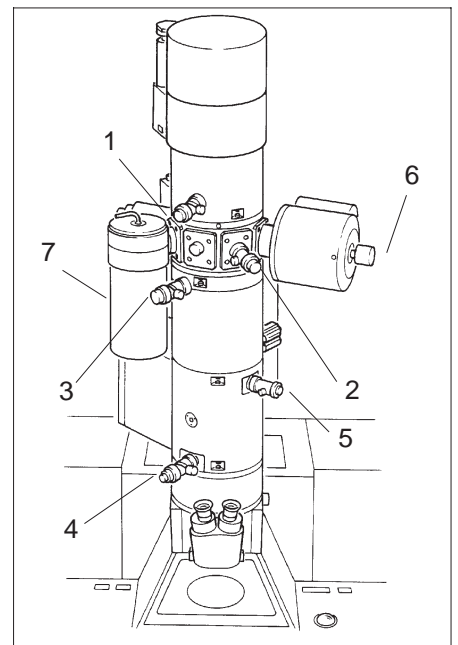
Other user data can be selected from the USER menu and called with RECALL USER DTA. The START menu will be reactivated. The desired user parameters are activated with the START key and set by the instrument.



If a green "READY" is displayed in the field GUN, the LEO 912 OMEGA is ready for high-voltage turn-on and beam generation. The LEDs on the control panels shine.

Before turning on the electron beam

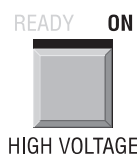
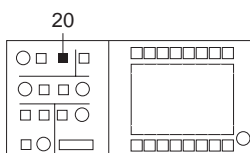
- **All apertures (1, 2, 3, 4, 5) should be retracted.**
If not, do so by turning knurled knob on aperture drive counter-clockwise to the stop.
- **Pull back specimen rod (6)**
- **Set magnification to approx. 8,000x.**
Adjust illuminating aperture to approx. 0.2mrad.
- **Fill anticontaminator (7) with liquid nitrogen, if necessary.**



WARNING:

Follow the *safety precautions for the use of liquid nitrogen* (chapter 2).

- **Turn on high voltage with key HIGH VOLTAGE (20) in the field GUN.**
 - Display LED ON on top of key HIGH VOLTAGE is blinking as long as the HV is not reached.
 - High voltage is set to the preset value.



4.2 High-voltage selection

Which high voltage is selected depends on

- the specimen thickness: thicker specimens require higher high voltage,
- the desired contrast,
- the desired resolution.

The contrast increases with *decreasing*, and the resolution with *increasing* high voltage. A suitable compromise must be achieved for each application.

Procedure

- Call menu GUN with softkey GUN of main menu.

GUN

G U N P A R >	VARIABLE H U			<60 KV>	<80 KV>	<100 KV>	<120 KV>
M A G : 4 0 0 0 x		G U N		<div style="border: 1px solid black; padding: 2px; display: inline-block;">120</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">100</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">80</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">60</div>			
FILAMENT CUR.: 0.00 A		EMISSION CUR.: <1 µA		LIMIT: 3.00 A		LIMIT: 50 µA	
STATUS: VAC:NO, HV:OFF, FILAMENT:OFF,				WARM UP 4000 mA/s		LIFE TIME: 0 HOURS	
MODE: < M > < IMAGE >				<div style="border: 2px solid black; padding: 2px; display: inline-block;">TUNGSTEN</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">TUNGSTEN</div>			
SPOT SIZE : 10 nm							
RETURN<	RECALL GUN ALIGN	FIL. CURRENT	FIL. PRECENT.	BEAM ALIGNM.	WOBBLE H U		RESET LIFETIME

- Select high voltage with the softkeys in the upper row.
- Key field of selected value highlighted.



SPECIAL NOTE:

When turning on or changing the High-voltage the beam blarker is activated to protect the specimen. This is displayed in the main menu, and the LED ON is blinking till the High voltage has reached its value. After approx. 20s the Beam Blarker is deactivated and the electron beam released again.

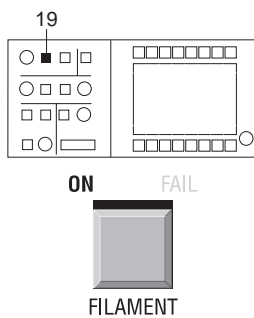
4.3 Basic settings after turn-ON



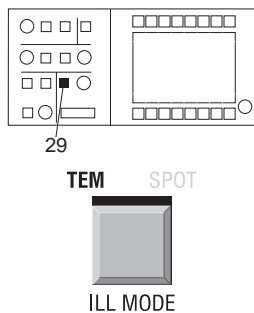
SPECIAL NOTE:

The alignment state of the instrument is identical when turned ON and OFF because of the digital storage of the alignment parameters and automatic loading with instrument turn-ON. The alignment needs to be corrected only with worn filament or thermal changes, e.g. of the aperture position.

4.3.1 Insertion of condenser aperture

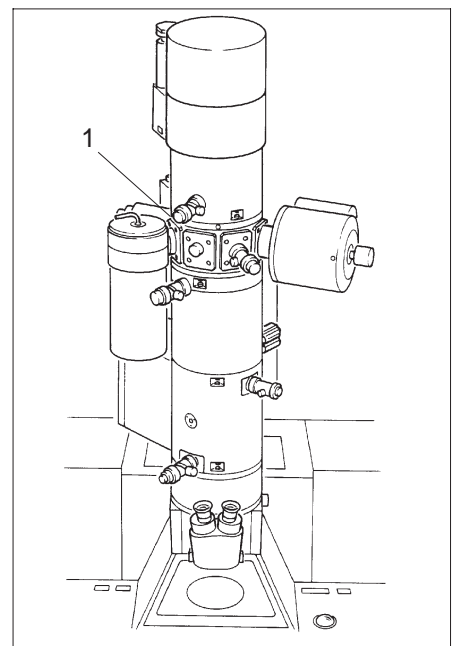


- Switch on filament with key FILAMENT (19) in the field GUN.

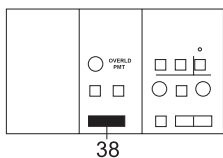


- Activate TEM illumination mode (29)
- Insert condenser aperture (1) (fixed aperture or third clickstop of AIS aperture).
- For AIS aperture:
Deactivate AIS mode.
- Center luminous field to index point with knobs on condenser aperture drive.
- For AIS aperture:
Activate AIS mode.

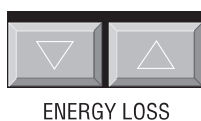
For further details see section 4.3.3



4.3.2 Spectrometer adjustment



- Set δE display of main menu to 0 eV.
You have the following choices:
 - with double key ENERGY LOSS (38) in field SPECTROMETER, or
 - with softkeys δE DOWN or δE UP of the menu δE (see section 3.9), or
 - with the softkey RESET δE of the menu δE (see section 3.9)



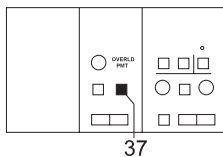
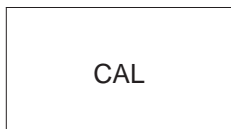


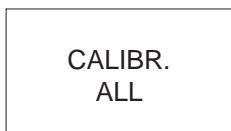
IMAGE SPEC



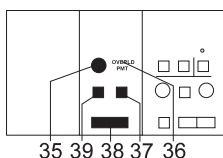
- Switch key IMAGE/SPEC (37) in field SPECTROMETER to SPEC.
The projector lens system 2 is focused on the energy dispersive plane.



- Push softkey CAL of menu PARAMETERS.
The menu CALIBRATE is called (see also section 3.4.1).



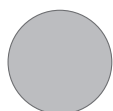
- Calibrate the image and illumination system with softkey CALIBR. ALL.



SHIFT FOCUS



- Set key SHIFT/FOCUS (39) in field SPECTROMETER to SHIFT.

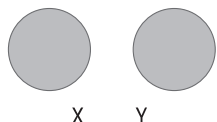
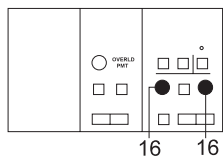


- Set caustic tip to center index on focusing fluorescent screen with knob (35).

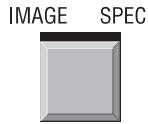
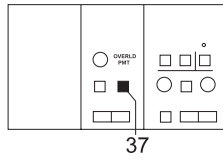


SPECIAL NOTE:

The shift is made in the energy dispersive direction. For a shift at right angles to this direction, use the encoder Y (16) of the *image shift* function.



CAUTION
The encoder X (16) in the field IMAGE is effective in energy dispersive direction. It **must not** be used to calibrate the spectrometer.

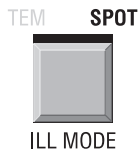
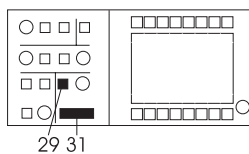


- Switch key IMAGE/SPEC (37) in field SPECTROMETER to IMAGE.
Projector lens system 2 is focused on the achromatic image plane.

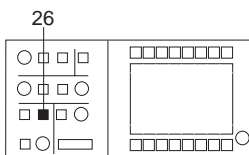
4.3.3 Adjustment of illumination system

In TEM ILLUMINATION mode the luminous field can be centered on the fluorescent screen either mechanically by shifting the condenser aperture or electrically with the encoders ILL. SHIFT X, Y. Electrical SPOT ILL. centration is required for exact mechanical condenser aperture alignment.

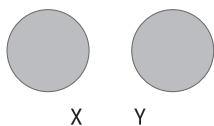
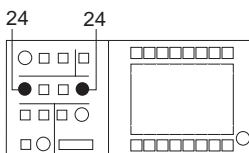
Procedure:



- Activate SPOT mode with key ILL. MODE (29), adjust for 100nm spot size with buttons (31).

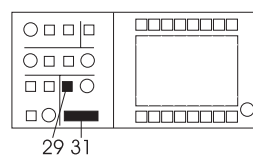
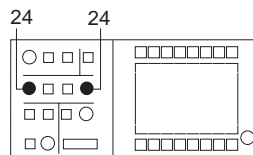
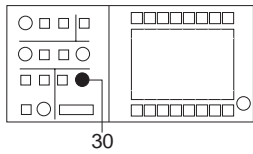


- Calibrate objective lens to eucentric axis with key CALIBRATE (26) in field FOCUS.
 - The spot should be on the viewing screen.
 - If not decrease magnification somewhat until it appears.



- Center luminous spot to index point with encoders X and Y (24) in field ILLUMINATION.

Version 3.20



- If necessary, focus spot to minimum diameter with encoder SPOT FOCUS (30) in field BRIGHTNESS.
 - If the brightness is too high focus later at a higher magnification.

SPECIAL NOTE:

The fluorescent screens are sensitive to excessive brightness for a longer time. The critical modes for the screens are diffraction, spectrum and spot. The BEAM BLANKER function protects the screens.

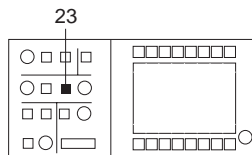
- Center condenser aperture mechanically until the spot is symmetric. For the further procedure it is provided that the AIS aperture was inserted (third click stop).
- Increase magnification to 31.500x and readjust spot to the center with encoders X and Y (24).
- Increase magnification to 125.000x and readjust spot to the center with encoders X and Y (24).
- Switch back to TEM illumination mode with button (29) and adapt brightness with buttons (31) that luminescent field is visible on the viewing screen.
- Center AIS aperture to the large screen.
 - The central AIS aperture (37,5 μm) has approx. the size of the large screen at this magnification.
 - After turning on the beam it will take some time to stabilize the AIS aperture. The centering of the AIS aperture should be repeated from time to time.

4.3.4

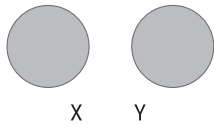
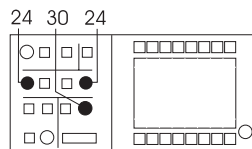
Compensation of SPOT astigmatism



The shape of the luminous spot focused to minimum diameter is circular or slightly elliptical. Illumination astigmatism exists if the axial orientation of the luminous spot rotates through 90° during through-focusing with the encoder SPOT FOCUS.



DEFL STIG

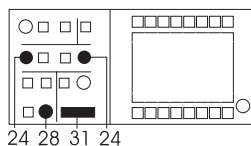


- Set encoders X and Y in field ILLUMINATION to the function *illumination stigmator*. Push key DEFL / STIG (23): Display STIG is on.
- With encoders X and Y (24) in field ILLUMINATION adjust illumination stigmator so that any noticeable rotation of the elliptical luminous spot disappears during through-focusing with encoder (30).

4.3.5

Beam Alignment

GUN PAR>	VARIABLE HU			<60 KV>	<80 KV>	<100 KV>	<120 KV>
MAG :	4 0 0 0 x	G U N				120	
FILAMENT CUR. :	0.00 A	LIMIT :	3.80 A		100		
EMISSION CUR. :	<1 μA	LIMIT :	50 μA		80		
STATUS :	VAC:NO, HV:OFF, FILAMENT:OFF,	WARM UP :	4000 mA/S		60		
		LIFE TIME :	0 HOURS				
MODE :	< M > < IMAGE >	TUNGSTEN					
SPOT SIZE :	10 nm	TUNGSTEN					
RETURN<	RECALL GUN ALIGN	FIL. CURRENT	FIL. PRECENT.	BEAM ALIGNM.		WOBBLE H U	RESET LIFETIME



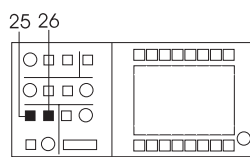
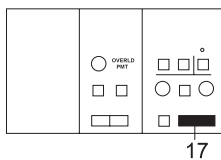
ILL APERTURE / SPOT SIZE



MAGNIFICATION

- Activate the function BEAM ALIGN: in th GUN menu.
 - The function key is highlighted. The digital values of the actual beam alignment are displayed.
 - The encoders X and Y (24) in the field ILLUMINATION are valid for the beam alignment. All other functions of the encoders are deactivated.
 - The function key STORE GUN ALIGNM. is displayed as long as the BEAM ALIGNMENT function is active.
- Insert the retracted specimen holder (loading specimen see section 4.5.1).
 - For the different alignment steps a test specimen (carbon foil) is recommended.
 - The test specimen might stay in one of the two positions of the holder.
- Find a specimen area and switch to diffraction with button (14).
 - The diffraction pattern of the carbon foil is visible on the screen.
- Select a camera length of 580 mm with buttons (17).
- Focus zero order beam with encoder OBJECTIVE (28).
- Set illumination angle to 0.06 mrad with buttons (31).
- Center the zero beam on the index point with encoders IMAGE (16).
- Increase the illumination angle to 1.6 mrad with buttons (31)
- Center the zero beam on the index point with **encoders X and Y (24)**.

4.3.6 Adjustment of the eucentric plane



- Repeat the last four steps until the zero beam doesnot change its position between 0.06 mrad and 1.6 mrad.
- Push button STORE GUN ALIGNM. in the GUN menu and answer PROCEED ? with Y(es).
 - The new beam alignment values are stored
- Push button RETURN to call the main menu.
 - The BEAM ALIGNM. function is deactivated automatically.
 - The illumination encoders (24) can be used for their displayed functions again.
- Switch back to image mode with button (14).

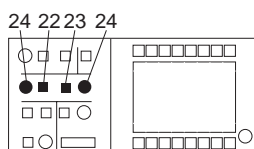
- Select magnification 25.000x with buttons (17) and adapt the brightness to this mag.
- Move specimen detail to the center of the small screen.
 - If there is not sufficient contrast, insert objective lens aperture (for operation see section 4.3.8)
- Calibrate objective lens current with button CALIBRATE (26).
- Switch on focus aid with button AID (25).
 - Illuminated ON indicates focus aid is active.
 - Specimen detail is moving.
- Focus specimen mechanically with Z control buttons
 - Detail doesnot move anymore.
 - Specimen is in the eucentric plane of the goniometer.
- Switch off focus aid with button (25).

4.3.7

Adjustment of beam incidence

- Use the same specimen detail to check the beam incidence.
- Center high-contrast image detail to index point.
- Activate key WOBBLE OBJ. FOC of menu FOCUS PARAMETERS.
 - Specimen detail is moving on the screen by the wobble frequency.
 - Illumination is tilted.

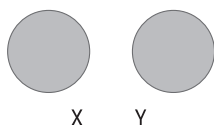
DISPLAY DEFOCUS	CHECK DEFOCUS	WOBBLE OBJECTIVE					
<p>MAG : 20000 x FOCUS PARAM.</p> <p>FOCUS STEP MODE: MAG.-DEPENDING FOCUS STEP</p> <p>FOCUS STEP: 36 nm</p> <p>DEFOCUS MODE: OFF</p> <p>DEFOCUS: 0 nm</p> <p>MODE: < M > < IMAGE ></p> <p>ILLUM. ANGLE : 0.10 mrad</p> <p>EMISSION CUR. : < 1 μA</p>							
RETURN<	MAG.-DEP. DEFOCUS	FIXED DEFOCUS	SELECT DEFOCUS	SCHERZER DEFOCUS	MAG.-DEP. FOC. STEP	FIXED FOC. STEP	SELECT FOC. STEP



TILT SHIFT

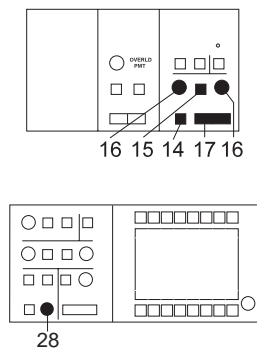


DEFL STIG



- Activate function illumination tilt with keys TILT (22) and DEFL (23).
- Adjust image detail with encoders X, Y (24) so that it stands still.
- Deactivate the function WOBBLE OBJECTIVE in the FOCUS PAR menu.
- Return to main menu.
- Set function SHIFT (22)
- Activate AIS mode in the main menu.

4.3.8



Centration of objective lens aperture

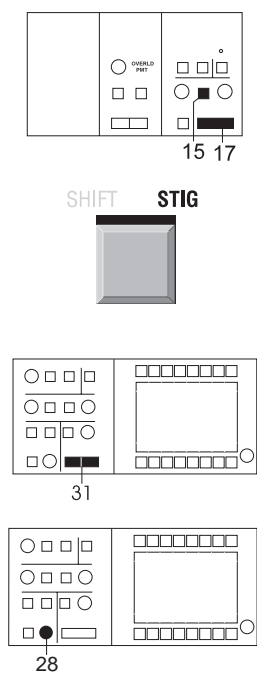
Only possible with a specimen in the beam path.

- Activate DIFF mode (14) and set CL = 580mm with buttons (17).
- Activate function *image shift* with key IMAGE / SHIFT (15).
- Center zero beam of diffraction image to index point with encoders X and Y (16) in field IMAGE.
- Focus diffraction image with encoder OBJECTIVE (28) in field FOCUS.
- Insert objective lens aperture diaphragm (2) and center it to the zero beam of the diffraction image with the knobs on the aperture drive.
- Switch back to IMAGE mode with button (14)

SPECIAL NOTE:

The selector aperture (3) is optional. The condenser aperture acts as selector aperture at magnifications above 4,000x. The selector aperture is only used in the low mag range where it acts as a contrast aperture.

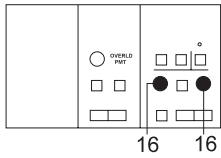
4.3.9



Compensation of imaging astigmatism

1st method: using the grain of the carbon film

- Activate image stigmator with key SHIFT / STIG (15) in field IMAGE.
- Set magnification to at least 125,000x with the keys MAGNIFICATION (17).
- Increase brightness with buttons ILL. APERTURE / SPOT SIZE (31), but not higher than 1 mrad.
If there is not enough brightness, increase the emission current by 1 or 2 steps.
- Through-focus image on fluorescent screen with encoder OBJECTIVE (28) in field FOCUS.



- With encoders X and Y (16) in field IMAGE adjust imaging stigmator so that the privileged direction of the grain structure disappears while through-focusing.

Astigmatism is exactly compensated if during through-focusing the grain structure is clearly visible near the focus and almost invisible when in focus. (Examples of astigmatism compensation see Figs. 4-1a to 4-1c)



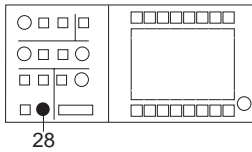
Imaging astigmatism exists if the grain structure of the film has a privileged direction (example showing astigmatism) and is visible also in focus.

2nd method: using Fresnel fringe in a hole of a carbon foil.

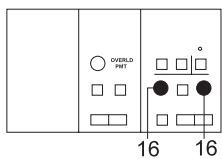
- Settings like those for method 1

The magnification used for compensation should be higher than the magnification used for exposure.

- Slightly overfocus with encoder OBJECTIVE (28) in field FOCUS. A diffraction fringe is noticeable near the edge of the hole.



Imaging astigmatism exists if the Fresnel fringe is not concentric to the edge of the hole when in slight overfocus (4-1d to 4-1e).



- With encoders X and Y (16) adjust imaging stigmator in field IMAGE so that the Fresnel fringe is concentric to the edge of the hole.

Astigmatism compensated

Astigmatism existent

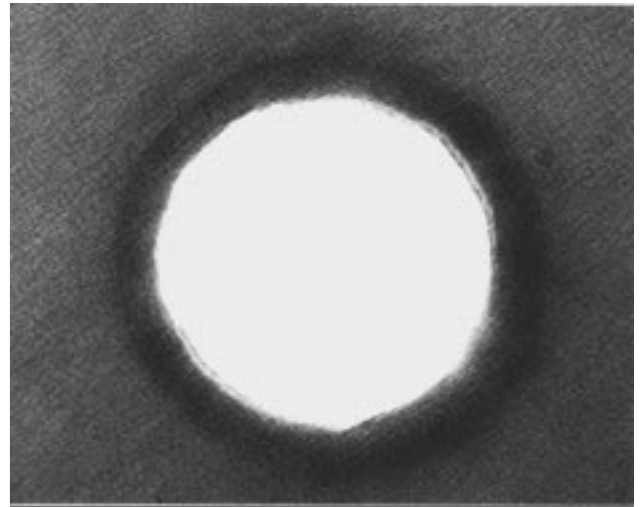
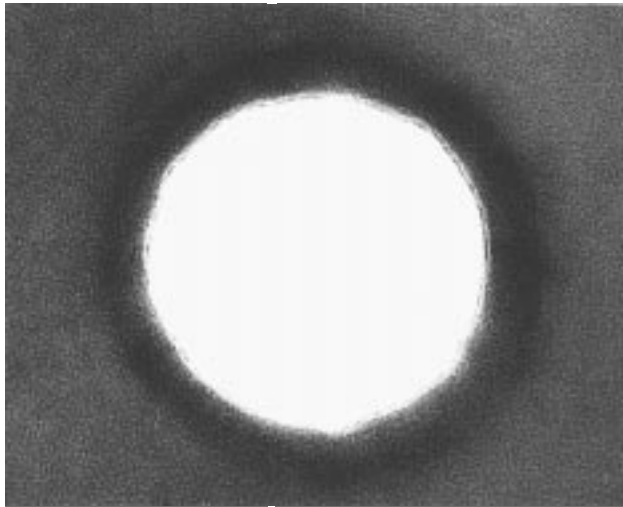


Fig. 4-1a: Overfocus

Fig. 4-1d: Overfocus

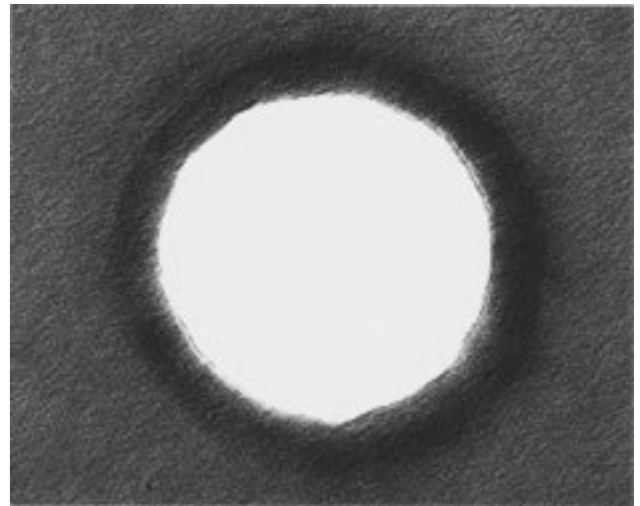
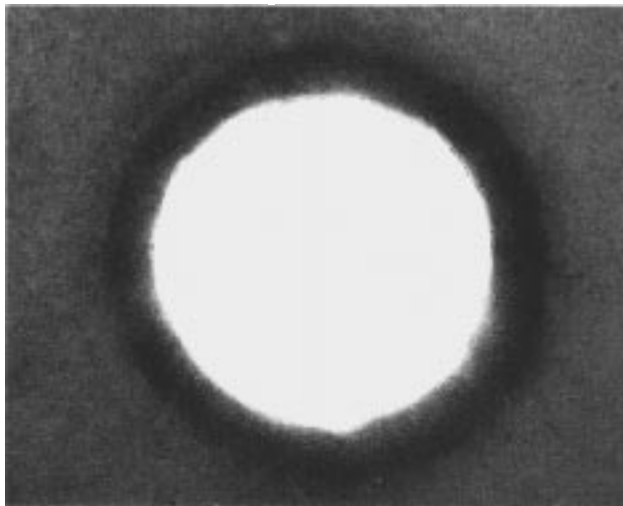


Fig. 4-1b: Near focus (grain almost disappears)

Fig. 4-1e: Near focus (grain remains visible)

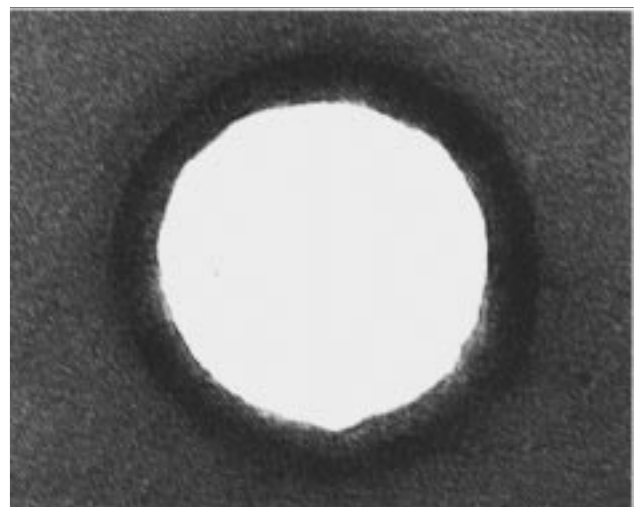
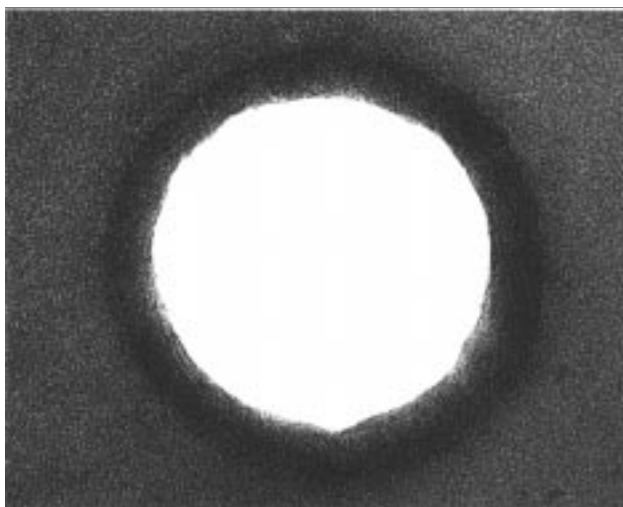


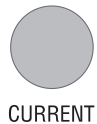
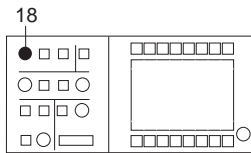
Fig. 4-1c: Underfocus

Fig. 4-1f: Underfocus

Version 3.20

4.4 Microscope settings

4.4.1 Emission current



The emission or beam current is adjusted with the encoder CURRENT (18) in field GUN. Raising or lowering the emission current increases or reduces

- the brightness of the image on the fluorescent screen, and
- the exposure of the specimen to irradiation.

24 steps are available for adjustment, of which 6 are active. These are in the middle of the 24-step range if the filament height is exactly adjusted. If the distance between filament and Wehnelt aperture is not exactly adjusted, the 6 active steps are higher or lower in the range.

If the emission current is increased beyond the set limit (menu GUN), the system is automatically readjusted to the permissible emission current.



SPECIAL NOTE:

The emission current should not be higher than necessary for specimen protection. The computer monitors the limit of the emission current as a function of the high voltage. The limit is max. 200 μ A for 20kV and max. 50 μ A for 120kV. Limit and emission current steps are displayed by the menu GUN. The emission current can be read on the analog display of the GUN menu or on the high-voltage cabinet.

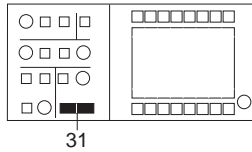
4.4.2 Filament current

The adjustment of the filament current is closely linked with the emission current. To lengthen the life of the filament, the filament current should not be higher than necessary in each specific case. But the filament heating should be high enough to guarantee the required emission current. If the brightness drops when increasing the emission current the filament is overheated for the required emission current: the image becomes darker instead of brighter.

For adjustment of the filament current see section 3.5 (menu GUN, softkey FIL. CURRENT).

4.4.3

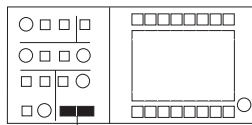
Image brightness



31



ILL APERTURE / SPOT SIZE



31



ILL APERTURE / SPOT SIZE



UTI

Brightness adjustment by the emission current (section 4.9.1).

After adjustment of this parameter the image brightness is changed with the double key ILL. APERTURE / SPOT SIZE (31) in the field BRIGHTNESS. Depending on the illumination mode the following parameters are influenced:

- TEM illumination mode: surface brightness
- SPOT illumination mode: spot brightness and size

Increasing the magnification with constant illuminating aperture reduces the image brightness, and vice versa.

The actual illuminating aperture is displayed on the control monitor in the line ILLUMIN. ANGLE (TEM illumination) or SPOT SIZE (SPOT illumination).

For constant brightness independent of the magnification activate the function CONSTANT BRIGHTNESS. In this mode the illuminating aperture is automatically adjusted when changing the magnification, so that the image brightness retains the value it had during activation of the function.

It is possible at higher magnification to use a defocused spot in SPOT mode.

Procedure

- Adjust brightness to desired value with double key ILL. APERTURE / SPOT SIZE.

Call function CONSTANT BRIGHTNESS by

- call of menu UTILITIES from PARAMETERS menu with softkey UTI.

	EDIT BAC. CALL			IMAGE ROTATION	H R MODE	FOCUS AID D O W N	FOCUS AID U P
<p>M A G : 4 0 0 0 x</p> <p style="text-align: right;">U T I L I T I E S</p> <p>START UP TIMES : 30</p> <p>MODE: < M > < IMAGE ></p> <p>SPOT SIZE : 10 nm</p> <p>EMISSION CUR.: <1 μA</p> <p style="text-align: right;">EXP. TIME: sec</p> <p style="text-align: right;">FIX TIME: 2.4 sec</p> <p style="text-align: right;">FILM SUPPLY: 02</p>							
RETURN<	CONST. BRIGHTN.	BEAM BLANKER	X <--> Y		ILL. SHIFT F I N E	BRIGHTN. FINE	

CONST.
BRIGHTN.

- Push softkey CONST. BRIGHTN.
- Key field highlighted.
- Illuminating aperture and displayed value change automatically with the selected magnification.

WARNING:
 The exposure of the specimen to irradiation increases with increasing magnification at constant brightness!

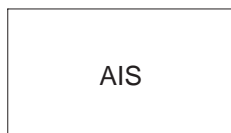
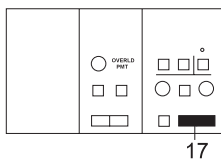
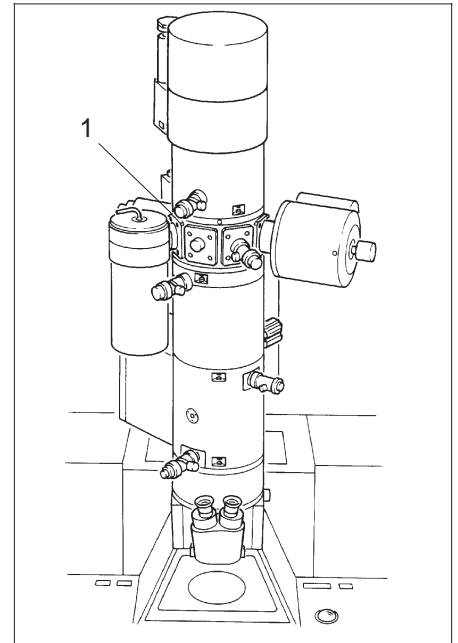
4.4.4

AIS

AIS (Automatic Illumination-aperture Selection) is used for magnifications from 4,000x. It must be in the beam path, if the AIS mode is activated in the main menu.

AIS mode is recommended:

- for specimen protection.
Only the area which is imaged is illuminated.
- to obtain optimum contrast.
Scattering electrons are masked out.
- for images in SPOT illumination.
The smallest aperture is automatically adjusted (important for analysis, diffraction and scanning mode).
- for selected-area diffraction.

**Procedure**

- Select magnification 3.150x with double key MAGNIFICATION (17).
- Adjust central aperture of 5-hole AIS aperture.
Turn knurled knob on condenser aperture drive (1) clockwise to 3rd clickstop.
- Activate AIS mode by pushing softkey AIS in main menu.

The C3 setting is automatically calibrated. The Beam Blanker is activated during calibration. The electron beam will then be invisible for a short period.

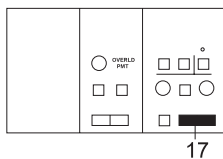
**SPECIAL NOTE:**

If astigmatism shows up with magnification change or asymmetric limitation of the fluorescent screen by the luminous field,

1. Check BEAM ALIGNMENT
2. Check AIS alignment in AIS ADJUST menu.

4.4.5

Magnification selection



With preselected IMAGE mode the magnification is adjusted in steps by the double key MAGNIFICATION (17) in the field IMAGE:

- Every time the left key MAGNIFICATION (t) is pushed the preselected magnification is reduced by approx. 25%.
- Every time the right key MAGNIFICATION (s) is pushed the preselected magnification is increased by 25%.

There are two ranges:

- M = 80x to 2,000x in 15 steps in LOW MAGNIFICATION (LM) mode
- M = 3,150x to 500,000x in 23 steps in MAGNIFICATION (M) mode

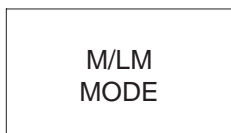
The control monitor displays the adjusted magnification and mode.



The special modes darkfield imaging (DF), cone illumination, AIS and Minimum Dose Focusing (MDF) can be applied only in M mode.

Procedure

- Select magnification mode with softkey M / LM MODE of the main menu.



P A R >	G U N >	G O N >	C A M >	U A C >	δ E >	I M A G E >	E X I T <
MODE: < M > < IMAGE >				SPECIMEN POSITION:			
M A G : 6 3 0 0 x				X = +6 9 3 3 μm		Y = +6 9 3 3 μm	
ILLUM. MODE: < T E M > < B F >				Z = +6 9 3 3 μm		θ = -8 2.0 °	
ILLUM. ANGLE : 0.10 mrad							
HIGH VOLTAGE: 120.00 kV							
EMISSION CUR.: < 1 μA							
δ E: 0 eV							
FOCUS STEP: 120 nm				EXP. TIME: sec		FIX TIME: 38.2 sec	
DEFOCUS: 0 nm				FILM SUPPLY: 20			
M / L M MODE		BEAM BLANKER	D F MODE	A I S MODE	M D F MODE	DISPLAY DEFOCUS	D S A



SPECIAL NOTE:

The AIS aperture and the objective lens aperture must be removed in LM mode



MAGNIFICATION

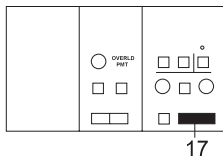


- Select magnification step with double key MAGNIFICATION (17).
With installed option FREE LENS CONTROL, free instead of stepwise adjustment is possible in the menu FREE MAGNIFICATION ADJUST.

SPECIAL NOTE:
The image is rotated through approx. 180° when changing the magnification from 25,000x to 31,500x.

SPECIAL NOTE:
When changing from 3.150x to 4.000x the Beam Blanker is shortly activated to protect the specimen.

4.4.6 Diffraction length selection



MAGNIFICATION

With preselected DIFFRACTION mode the diffraction or camera length (CL) is also selected in steps by the double key MAGNIFICATION (17) in the field IMAGE:

- Every time the left key MAGNIFICATION (t) is pushed the preselected camera length is reduced by approx. 25%.
- Every time the right key MAGNIFICATION (s) is pushed the preselected camera length is increased by 25%.

There are two ranges:

- CL = 10m to 800m in 23 steps in LOW ANGLE (LA) mode
- CL = 290mm to 7,200mm in 15 steps in M mode

The control monitor displays the selected camera length and mode.

4.5 Microscopy

4.5.1 Specimen exchange



SPECIAL NOTE:

The specimen rod, especially the specimen carrier on the tip of the rod, should be handled and stored with utmost care to prevent even minute bending, contamination or damage of the sapphire bearing.

Touching the specimen rod or contamination causes longer pumpdown time, poor vacuum, increased specimen contamination and wrong results in element analysis!

WARNING concerning the use of the BERYLLIUM specimen rod! Any contact of the beryllium specimen rod with the bare skin should be avoided. If the beryllium specimen rod is touched, the corresponding skin areas must be instantly rinsed with plenty of water. See also the safety precautions in chapter 2 for the handling of beryllium.

Required tools (standard accessories) for specimen exchange (see Fig. 4-2):

- Storage container for specimen rod
- Collet chuck
- Pointed tweezers

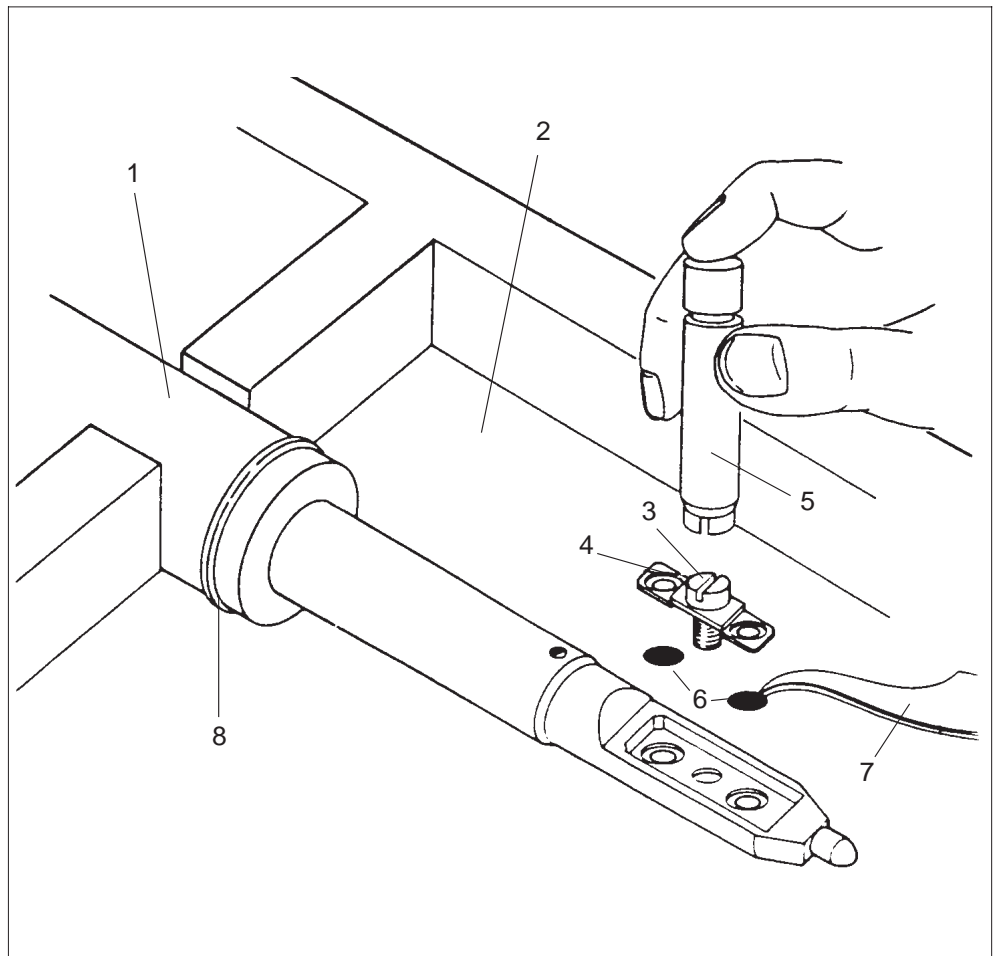


Fig. 4-2: Specimen rod tips with tools and specimen grids

Procedure

(see Fig. 4-2)

- Place specimen rod (1) in container (2) so that screw (3) of holding bow (4) is easily accessible.
- Put on collet chuck (5), loosen screw, lift it off together with holding bow and place it aside.
The screw is captivated in the holding bow.
- Turn specimen rod upside down, the specimen grids (6) will fall out. If the grids stick, push them out with tweezers (7).
- Turn back specimen rod, insert new grids, replace holding bow and tighten screw.



SPECIAL NOTE:

Check O-ring (8) for contamination before lock-in.

4.5.2 Specimen lock-in/out

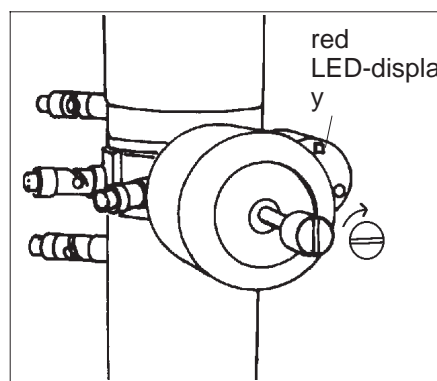


SPECIAL NOTE:

Lock-in/out is only possible if the red LED display STOP on the goniometer is out. If not, air will penetrate into specimen and filament chambers and the ion getter pump will shut off.

Rule:

No action if LED display STOP is on.



Lock-in

It is recommended for filament protection to switch off high voltage and filament heating before lock-in.

- **Slide specimen rod (1) carefully into goniometer as far as it will go. Pin (2) of specimen rod engages notch (3) on goniometer (Fig. 4-3a).**

The airlock program is activated automatically.

- **Turn specimen rod carefully clockwise all the way to *prevacuum* position (Fig. 4-3b).**

- Airlock valve V4 opens.
- LED STOP is on.
- Specimen rod pre-pumped in approx. 20s.
- LED STOP goes out if the defined vacuum threshold is reached.

- **Pull specimen rod back to the stop and turn it carefully through further 90° (Fig. 4-3c).**

Airlock valve V4 closes after leaving *prevacuum* position.

- **Push specimen rod slowly into *microscopy position* (Fig. 4-3d).**

WARNING:

Do not let go the specimen rod when turning it to microscopy position! Otherwise the vacuum would pull it too quickly into the opening and damage the sapphire bearing on the tip of the specimen rod.

Lock-out

Lock out in reverse order. No waiting time in *prevacuum* position.

- **Switch off filament heating and high voltage.**
- **Retract rod as far as it will go. Carefully turn it counterclockwise through 90° and pull back to the stop.**
- **Turn it counterclockwise through about 20° and pull it carefully out of the goniometer.**



SPECIAL NOTE:

The knurled knob on the specimen rod is provided with markings in the Figs. below to visualize the corresponding angular position of the rod. Accessory rods supplied with the LEO 912 OMEGA are not provided with these markings.

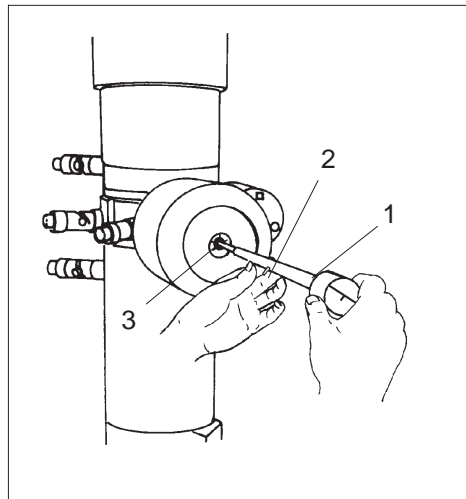


Fig. 4-3a: Insertion of specimen rod

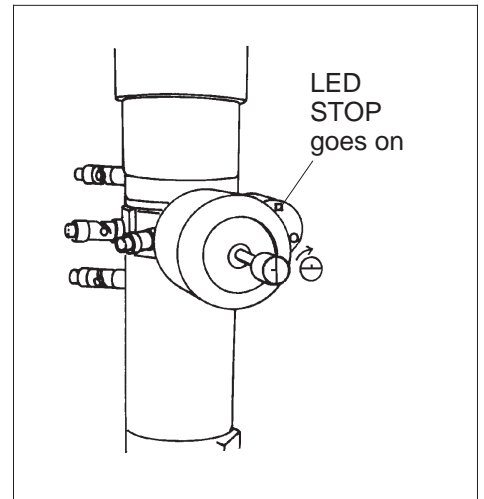


Fig. 4-3b: Preevacuation

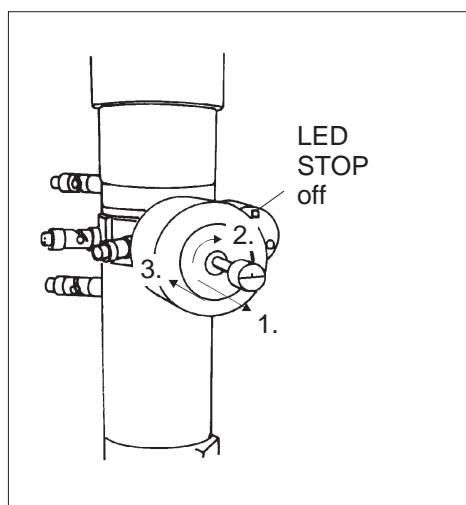


Fig. 4-3c: Preevacuation concluded

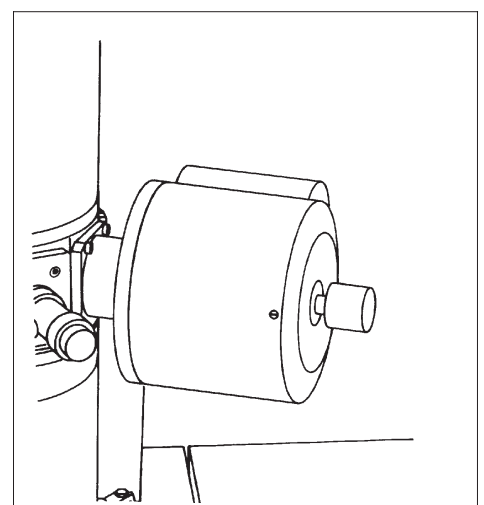


Fig. 4-3d: Microscopy

4.5.3

Change between specimens

Two specimen grids can be loaded in the carrier of the standard specimen holder. Either grid is brought into the beam path with the specimen changer (Fig. 4-4).

Only one specimen can be loaded in special rods, e.g. with a second tilt axis Φ or axis of rotation ϵ .

To observe the specimen on the *sapphire-side* (rod position see Fig. 4-5d):

- Turn outer knurled knob (1) counterclockwise and loosen specimen changer (Fig. 4-5a).
- Turn inner knurled ring (2) clockwise to the stop Fig. 4-5b). The sapphire-side specimen is inserted.
- Tighten outer knurled ring (2) (Fig. 4-5a).
- To observe the specimen on the *rod-side* (rod position see Fig. 4-5c) proceed as described above, but turn inner knurled ring counterclockwise to the stop.

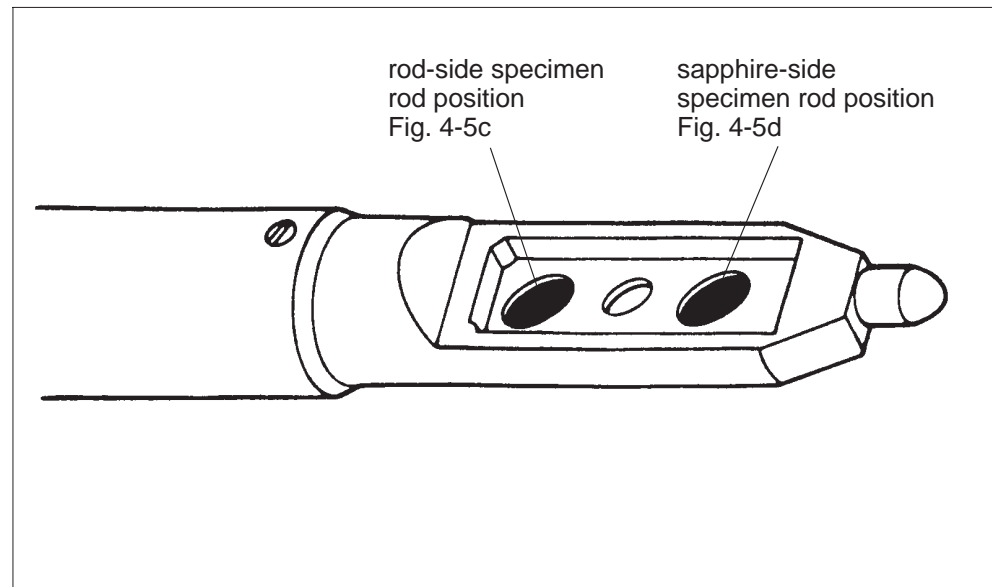


Fig. 4-4: Specimen rod position

Version 3.20

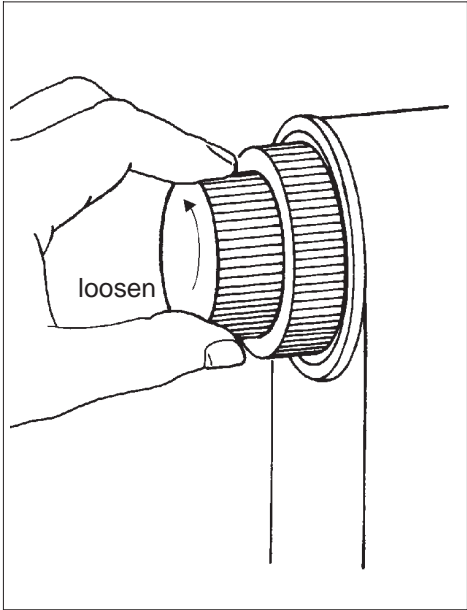


Fig. 4-5a: Outer knurled knob

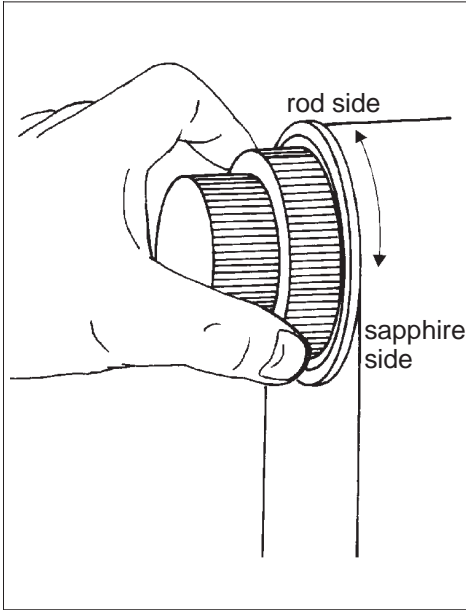


Fig. 4-5b: Inner knurled knob

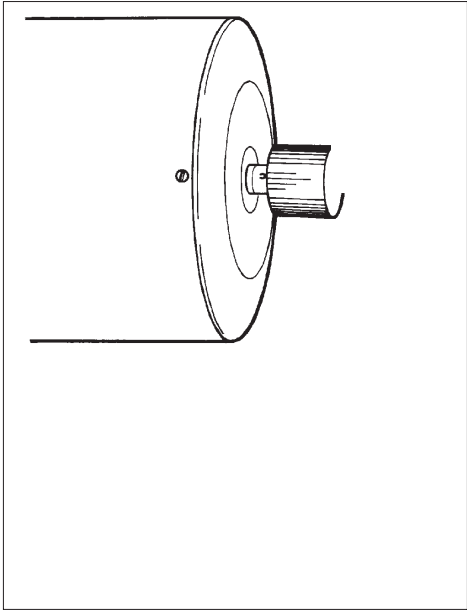


Fig. 4-5c: Rod-side specimen rod position

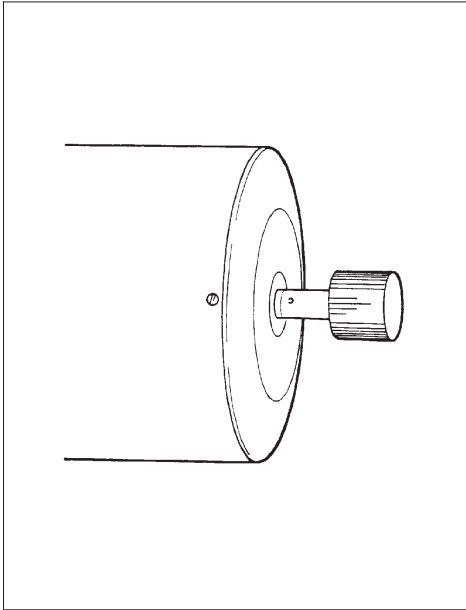


Fig. 4-5d: Sapphire-side specimen rod position

4.5.4

Use of the goniometer

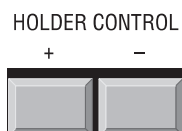
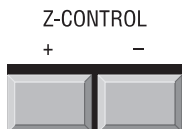
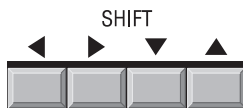
The goniometer is used for specimen screening. The specimen can be moved in the directions X, Y and Z, and in the eucentric plane tilted about the X axis (tilt angle Θ).

Optional, motorized specimen rods allow the following additional movements:

- Tilt of the specimen about the Y axis (tilt angle Φ) or
- Rotation of the specimen about the Z axis (angle of rotation ϵ)

The actual axis position is displayed by the main menu in the field SPECIMEN POSITION or by the menu GONIOMETER.

All goniometer axes are driven by electromotors operated by keys in the table top to the left and right of the column and by the trackball. Magnification compensation for the travelling speed means that with axis shift the image always moves at the same speed on the fluorescent screen, independent of the adjusted magnification.



- Key SHIFT +/- for X and for Y pushed:
 - **Coarse** specimen shift in a plane perpendicular to the optical axis. Max. distances from mid-position:
 - X_{\max} +/- 1 000 μm horizontal shift
 - Y_{\max} +/- 1 000 μm vertical shift
- Using the Trackball:
 - **Fine** specimen shift in any direction in a plane perpendicular to the optical axis.
- Key Z-CONTROL + or – pushed:
 - Specimen shift parallel to the optical axis. Max. shift from mid-position Z_{\max} : +/- 200 μm vertical specimen shift
- Key TILT + or – pushed:
 - Specimen tilt about the rod axis. Max. tilt angle from mid-position Θ_{\max} : +/- 60°

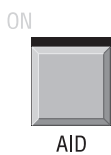
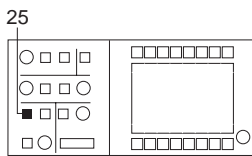
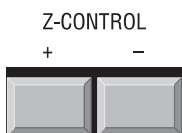
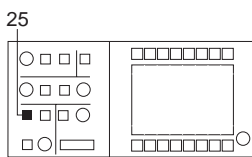
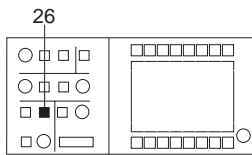
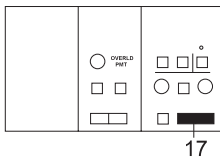
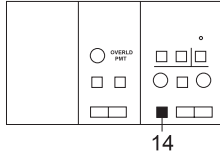
With incorporated optional double tilt or tilt/rotation rod:

- Operate key HOLDER CONTROL or footswitch (on request):
 - Double tilt rod
 - Specimen tilted about Φ -axis. Max. tilt angle from mid-position Φ_{\max} +/- 30°: Tilt axis at 90° to rod axis.
 - Tilt/rotation rod
 - Specimen rotated about the Z axis. Any angle of rotation ϵ possible.

4.5.5

Settings before screening

Before screening in the standard magnification range the optimum imaging plane must be adjusted:



- Activate TEM illumination and IMAGE modes with key IMAGE (14).
- Set magnification $M \geq 4000x$ with keys MAGNIFICATION (17).
- Calibrate objective lens to eucentric axis by pushing key CALIBRATE (26) in field FOCUS.
- Activate focusing aid with key AID (25) in field FOCUS.
- Shift goniometer Z axis with keys Z-CONTROL + and – until no image movement is seen.
- Deactivate wobbler with key AID (25).

The specimen is now on the eucentric axis.

The following values are referred to the optimum imaging plane:

- Magnification
- Camera length
- SPOT diameter
- eucentric tilt
- Correction of image aberrations.

4.5.6

Low magnifications (LOW MAG = LM)

Magnifications between 80x and 2,500x are adjustable in the LM range. Almost the entire specimen is imaged on the fluorescent viewing screen at 80x magnifications.

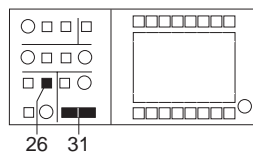
Adjust LM range for the location of specimen features

- Push softkey M / LM in main menu.

M/LM
MODE

P A R >	G U N >	G O N >	C A M >	U A C >	δ E >	I M A G E >	E X I T <
MODE: < M > < I M A G E >				SPECIMEN POSITION:			
M A G : 6 3 0 0 x				X = +6 9 3 3 μm		Y = +6 9 3 3 μm	
ILLUM. MODE: < T E M > < B F >				Z = +6 9 3 3 μm		θ = -8 2.0 °	
ILLUM. ANGLE : 0.10 mrad							
HIGH VOLTAGE: 120.00 kV							
EMISSION CUR.: < 1 μA							
δ E: 0 eV							
FOCUS STEP: 120 nm				EXP. TIME: sec		FIX TIME: 38.2 sec	
DEFOCUS: 0 nm				FILM SUPPLY: 20			
M / L M MODE		BEAM BLANKER	D F MODE	A I S MODE	M D F MODE	DISPLAY DEFOCUS	D S A

- Retract condenser aperture.
- Retract objective lens aperture.
- Select brightness with key ILL. APERTURE (31).



26 31

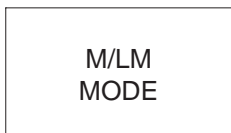
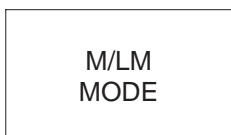
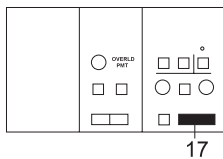


ILL APERTURE / SPOT SIZE



CALIBRATE

- Focus specimen with key CALIBRATE (26) in field FOCUS.



- Select magnification with keys MAGNIFICATION (17).

- Choose a specimen feature.

Switch back to M range.

- Return condenser aperture and objective lens aperture to previously adjusted positions.

- Switch back to M range with softkey M / LM.

Adjust image center of M range to LM range.

In the M and LM ranges there are separate data sets for:

- Magnification
- Illuminating aperture (brightness)
- Illumination shift and image shift

Pushbutton-operated change between LM adjustment with defined magnification and illuminating aperture, and M adjustment with differently defined magnification and illuminating aperture. A separate data set for image shift is also available, which allows exact adjustment of the image center in the LM range to the image center in the M range.

- Center easily recognizable image feature to the index point in the M range. Any magnification possible.
- Switch to LM with softkey M / LM in the main menu.
- Retract condenser aperture and objective lens aperture.
- Select LM MAG. Any magnification possible.
- At the desired magnification center identical image feature to index point with IMAGE SHIFT.

SPECIAL NOTE:

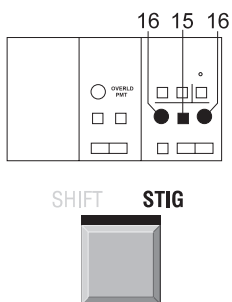
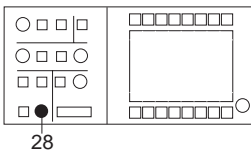
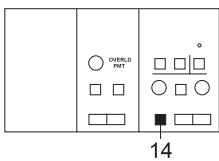
Change between the two magnification ranges is possible after the above adjustment; the image center is maintained.

Readjustment is necessary with any other magnification selected in the LM range!

SPECIAL NOTE:

Change between M and LM without removing objective lens aperture and condenser aperture is possible with certain limitations. From magnification $\geq 500\times$ the small AIS aperture ($37\ \mu\text{m}$) and a $90\ \mu\text{m}$ objective lens aperture will illuminate a field having just the diameter of the height of the focusing fluorescent screen.

M/LM
MODE



High-contrast imaging in LM mode

- Push softkey M/LM MODE of main menu.
- Retract objective lens aperture diaphragm.
- Shift specimen feature to center of fluorescent screen.
- Center suitable condenser aperture (luminous field).
- Adjust brightness with keys BRIGHTNESS.
- Adjust for DIFF mode with key IMAGE (14).
- Center selector aperture (option).
- Center slit aperture.
- Focus specimen feature with encoder OBJECTIVE (28) in field FOCUS (for the Gaussian focus use the function *focus aid*).
- Adjust for STIG mode with key SHIFT/STIG (15).
- Compensate astigmatism with encoders X and Y (16) in field IMAGE.

4.5.7



Systematic screening

- Call menu GONIOMETER with softkey GON in main menu.
The menu expands the goniometer facilities:
 - Max. 99 positions plus comments can be addressed, stored and recalled
 - Systematic meander screening of specimen (option)
 - Relocation of mid-positions of all axes (RESET)
 - Swinging tilt axis for adjustment of eucentric axis
 - Adjustment of tilt or rotation speed of Θ and, if installed, Φ or ϵ axis.

G O N P A R >	P O S S E R >	STORE POSIT.	EDIT COMMENT	AUTO STORE INC	AUTO REC. INC	RESET GON TILT	RESET POSITION
<p>M A G : 2 0 0 0 0 x G O N I O M E T E R</p> <p>CURRENT SPECIMEN POSITION: STORED SPECIMEN POSITION:</p> <p>X = +6933 μm X = -0000 μm Y = +6933 μm Y = -0000 μm Z = +6933 μm Z = +0000 μm θ = -82.0 ° θ = -00.0 °</p> <p>MODE: < M > < IMAGE > ADDRESS NO: 6 COMMENT: _____</p> <p>ILLUM. ANGLE : 0.10 mrad NUMBER OF FRAMES: 10 EMISSION CUR.: <1 μA</p>							
RETURN<	RECALL POSIT.	LAST ADDRESS	NEXT ADDRESS	EDIT ADDRESS	START POS. -SCAN	STOP POS. -SCAN	ADJUST EUC. AXIS

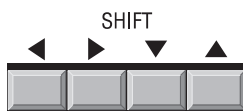


With optional *motorized special specimen rod* a code informs the LEO 912 OMEGA system control which rod is installed: *double tilt rod* with standard tilt axis Θ and extra tilt axis Φ or *rotation/tilt rod* with standard tilt axis Θ and axis of rotation ϵ . The menu GONIOMETER PARAMETERS lists automatically only the installed axes; either

- Θ (standard rod) only
- or Θ and Φ (double tilt rod)
- or Θ and ϵ (rotation/tilt rod).

The meander program (option) is used for motorized systematic scanning of a specimen within an area defined by 4 corner points. Specimen details of interest can be stored after scan interruption. Image format, speed and overlap are selectable. Manual (motorized) systematic specimen scanning is also possible.

For a detailed description of the menu GONIOMETER see section 3.6.



4.5.8

With lens program 1 (compensation of rotation with magnification change) the specimen is moved horizontally with the key SHIFT X +/- and vertically with the key SHIFT Y +/- . Fine shift in any direction with the trackball. The positions are displayed by the main menu, the menu GONIOMETER and various other menus.

Storage and location of specimen positions

Storage of a specimen position

- Call menu GONIOMETER with softkey GON.
- Push softkey STORE POSIT.
X/Y coordinates are stored under the displayed address number. Key AUTO STORE INC held down sets the following address number automatically after each storage.



SPECIAL NOTE:

Entry in the field COMMENT should be made before storage.

Relocation of a stored specimen position

- Select desired address number with LAST ADDRESS, NEXT ADDRESS or EDIT ADDRESS.

GON

STORE
POSIT.

LAST
ADDRESS

NEXT
ADDRESS

or

EDIT
ADDRESS

RECALL
POSIT

- Push softkey RECALL POSIT.

Stored specimen coordinates are set. Specimen position relocated with an accuracy of less than 1 μ m.

With activated function *auto rec. inc* the following address number is automatically set. A series of positions can be recalled by simply operating the key RECALL POSIT.

4.5.9

Further goniometer settings from the menu

Mid-position adjustment

The goniometer axes are shifted automatically to mid-position when the LEO 912 OMEGA electronics are switched ON (key switch in position ON). The mid-position can also be called by the following steps:

- Call menu GONIOMETER with soft key GON in the main menu.
- Push softkey RESET POSITION in menu GONIOMETER.
All goniometer axes are shifted to mid-positions.
- Softkey RESET GON TILT sets only the rod tilt axis to 0°.

Speed adjustment

Tilt and rotation speed of tilt axis Θ and extra tilt axis Φ (option) or axis of rotation ε (option) are variable in 8 steps by the menu GONIOMETER PARAMETERS. Necessary steps:

- Call menu GONIOMETER with softkey GON in main menu.
- Push softkey GON PARA in menu GONIOMETER.
- Select speed for the desired axis.



For a detailed description of the menu GONIOMETER PARAMETERS see section 3.6.1.

GON

RESET
POSITION

RESET
GON TILT

GON

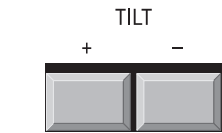
GON
PAR

4.5.10

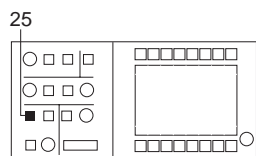
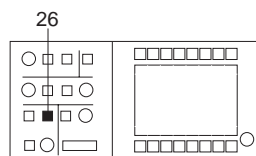
Eucentric tilt

Procedure:

- Select specimen feature by shifting it to the index point of the small fluorescent screen with goniometer keys X and Y or with the trackball.
- Set tilt angle Θ to 0° using either keys TILT + and – for goniometer tilt or activate softkey RESET GON TILT in menu GONIOMETER.



or



ON



Z-CONTROL



TILT



Z-CONTROL



- Calibrate objective lens to eucentric axis with key CALIBRATE (26) in field FOCUS.

- Wobble beam incidence with key AID (25) in field FOCUS.

- Correct vertical position with keys Z control + and – until the image stands still on the fluorescent screen.

- Deactivate AID.

- Tilt specimen feature with keys TILT + and – of the goniometer control

If the image moves, correct vertical position with keys Z CONTROL + and – until the image does not move any further on the fluorescent screen.



4.5.11

Other possibility:

- Activate softkey ADJUST EUC AXIS in menu GONIOMETER. The specimen rod is then arbitrarily tilted between + and – 12°.

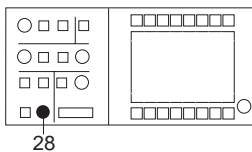
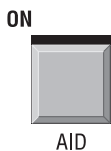
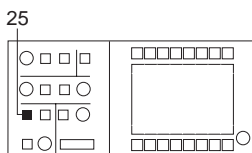
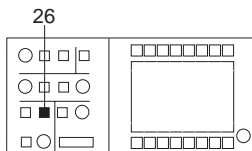
Adjustment of Gaussian focus

Because the contrast transfer function is dependent on the focusing, resolution and contrast are considerably dependent on the focus adjustment. The geometric-optical (Gaussian) focus is adjusted only in darkfield imaging and in ESI imaging with inelastically scattered electrons. In brightfield imaging the adjustment of the Gaussian focus is generally used only as origin for the selection of defined defocusing (Scherzer defocus).

With the LEO 912 OMEGA a specific defocus can be preselected and reproducibly adjusted for exposure by the host computer.

Presetting

- Adjust specimen feature to index point.
- Calibrate objective lens to eucentric axis with key CALIBRATE (26) in field FOCUS.

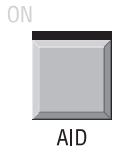


- Focus object mechanically (goniometer control Z).
- Optimize direction of beam incidence.
- Lower binoculars for observation.

Focusing with the wobbler

- Push key AID (25).
The direction of beam incidence is wobbled.

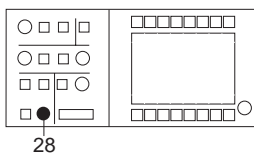
If the feature becomes unsharp and moves, focus with the encoder OBJECTIVE (28) until the feature in the center of the image does not move any further.



- Deactivate key AID (25).

Focusing using the grain

- Center condenser aperture ® 150 µm.
- Center objective lens aperture diaphragm ® 90 µm.
- Adjust for magnification | 50,000x.
- Center slit aperture.
- Adjust contrast minimum with encoder OBJECTIVE (28) in field FOCUS (correct astigmatism, if necessary).



Focusing for darkfield imaging

- Center condenser aperture.
- Adjust for DIFF mode with key IMAGE (14).

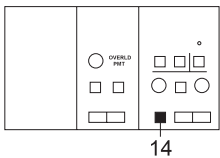


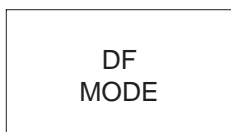
IMAGE DIFF



- Center objective lens aperture diaphragm.
- Focus aperture rim with encoder OBJECTIVE (28) in field FOCUS.

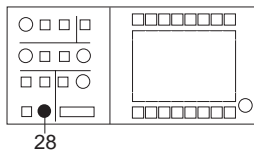
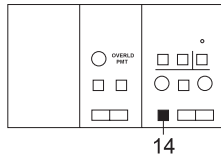
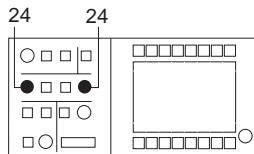


- Select menu DF in menu PARAMETERS.

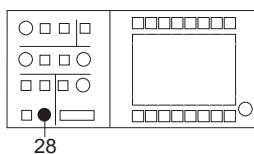
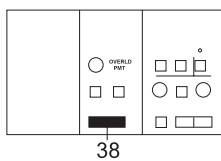


- Activate DF mode.

ADJUST
DF OFFSET



DF
MODE



- Push softkey ADJUST DF OFFSET.
- Shift diffraction spot beyond aperture rim with encoders X and Y (24) in field ILLUMINATION.
- Activate IMAGE mode with key IMAGE (14).
- Adjust for adequate brightness with keys BRIGHTNESS.
- Focus specimen feature with encoder OBJECTIVE (28) in field FOCUS.
- For brightfield imaging deactivate DF mode and reduce brightness.

Focusing for inelastic imaging (ESI)

- Center condenser aperture.
- Center objective lens aperture diaphragm.
- Center slit aperture.
- Adjust slit width so that the photographic format is fully illuminated.
- Adjust for approx. 30eV or characteristic energy loss with double key ENERGY LOSS (38).
- Adjust for adequate brightness with BRIGHTNESS keys.
- Focus inelastic image with encoder OBJECTIVE (28) in field FOCUS.
- For brightfield imaging reset δE value and reduce brightness.

Version 3.20

4.5.12 Focus and defocus parameters

The focus parameters influence the properties of the encoder OBJECTIVE in the field FOCUS. Changeable are:

Sensitivity (focus step size)

Selectable are:

- fixed step size
- automatic adaptation of step size to magnification

Operating mode

Choice between

- Continuous through-focusing in fine focus steps with automatic change of coarse focusing range
- Focusing without changing the range

Defocus

SPECIAL NOTE:

No defocus should be adjusted for exposures with inelastically scattered electrons ($\delta E > 0$); the result would be unsharp images.

For various applications, e.g. biological sections or crystalline specimens, not the Gaussian focus is used for exposure but a defined defocus which produces phase contrast required to observe certain structures.

In the LEO 912 OMEGA the defocus is adjustable by the host computer and the following modes can be selected (see Fig. 4-6):

- Defocus off: individual defocus
- Fixed Defocus defocus adjustable from 4nm - 64 μ m in 4nm steps
- Scherzer Defocus defocus is automatically adjusted to the high voltage

HV (kV)	60	80	100	120
Δf (nm)	120	112	104	100
- Mag. Dep. Defocus defocus is automatically adjusted to the magnification
- Display Defocus defocus is adjusted by the user

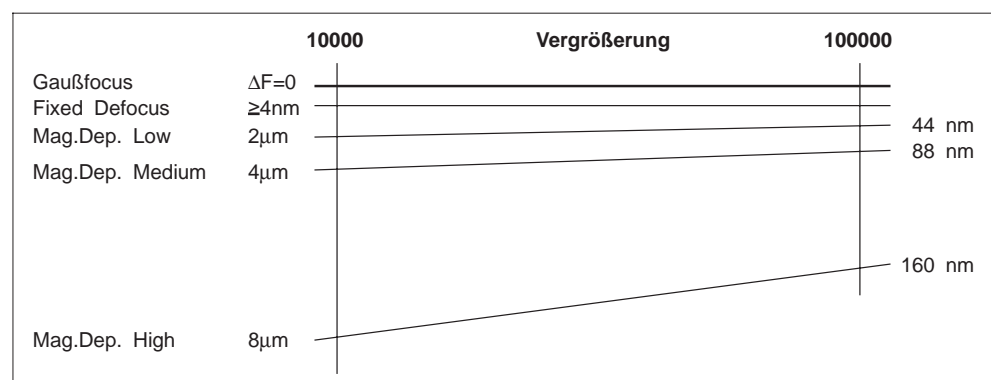
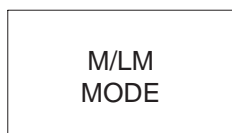
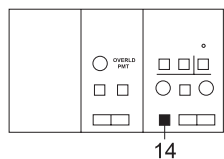


Fig. 4-6: Defocus modes (values see table in section 3.4.6, menu FOCUS PARAM.)



Procedure

to adjust the focus and defocus parameters

- Activate IMAGE mode with key IMAGE (14) in field IMAGE.

- Select magnification mode M in main menu.

SPECIAL NOTE:

The selected defocus value is displayed by the main menu and the CAMERA menu and imprinted on the negative. Without selected defocus, 0µm. is imprinted on the negative as defocus value.

To call the menu FOCUS PARAMETERS

- Push softkey PAR in main menu.

- Push softkey FOCUS PAR in menu PARAMETERS. Menu FOCUS PARAMETERS is displayed.

- Select focus step.

- Select defocus mode.
For a detailed menu description see section 3.4.8.

Version 3.20

DISPLAY DEFOCUS		CHECK DEFOCUS	WOBBLE OBJECTIVE				
<p>MAG : 20000 x FOCUS PARAM.</p> <p>FOCUS STEP MODE: MAG.-DEPENDING FOCUS STEP</p> <p>FOCUS STEP: 36 nm</p> <p>DEFOCUS MODE: OFF</p> <p>DEFOCUS: 0 nm</p> <p>MODE: < M > < IMAGE ></p> <p>ILLUM. ANGLE : 0.10 mrad</p> <p>EMISSION CUR. : <1 μA</p>							
RETURN<	MAG.-DEP. DEFOCUS	FIXED DEFOCUS	SELECT DEFOCUS	SCHERZER DEFOCUS	MAG.-DEP. FOC. STEP	FIXED FOC. STEP	SELECT FOC.STEP



The menu can only be called with previously adjusted IMAGE mode and magnification mode M.
Change to DIFF mode is impossible in the menu FOCUS PARAMETERS.

4.6 Viewing binocular adjustment

The 9x binoculars are used to observe the image on the fluorescent screen. They can be focused on the small fluorescent screen and shifted across the entire screen (1) width. The binoculars must be adjusted to the user's eyesight before microscopy:

- The emmetropic user sets both eyepieces (2) to 0 dpt. (Fig. 4-7).
- The ametropic user adjusts the diopter value separately for each eyepiece according to the diopter value of his eyeglasses.
- PD adjustment by turning the binocular tubes (3) in or out.

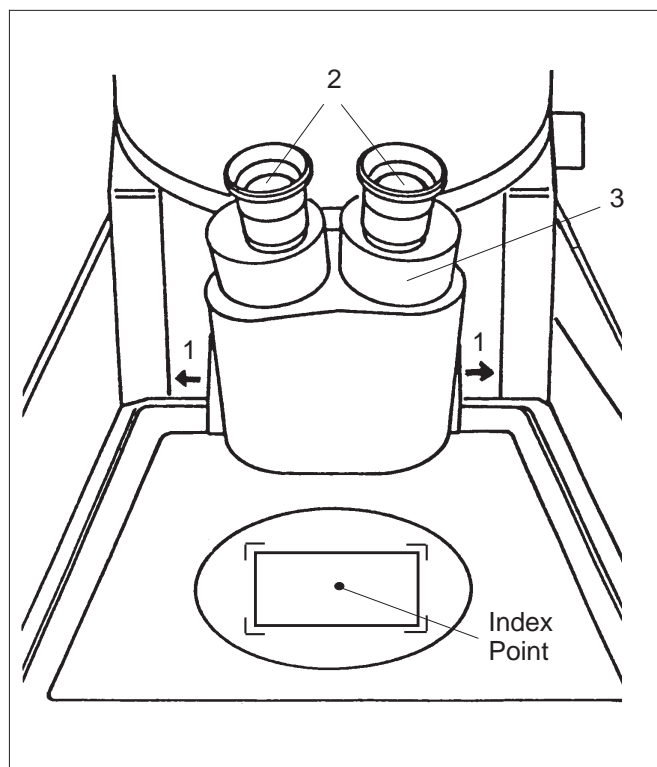


Fig. 4-7: Adjustment of viewing microscope

4.7 ESI imaging modes

4.7.1 Elastic imaging

Elastic imaging is recommended when **high-quality exposures** are wanted. It is of advantage for conventional preparations, especially **low-contrast, thin or thick specimens**.

Elastic imaging always improves the contrast, and also the resolution of thick specimens and in darkfield imaging.

It can be used for brightfield, darkfield and diffraction imaging.

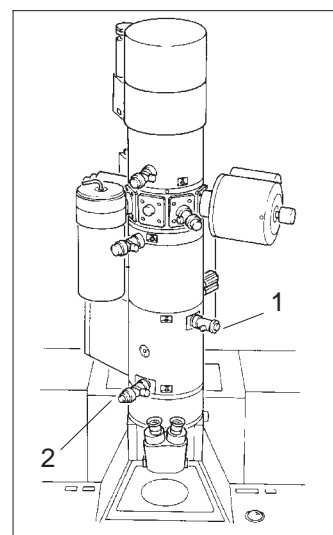


Differences in comparison with global imaging:

The slit is provided in the beam path. It allows only selected electrons to pass, here, only unscattered electrons, or monoenergetic electrons elastically scattered under low angles.

Procedure:

- Lock in specimen and center.
- Adjust for approx. 10,000x magnification.
- Adjust for homogeneous illumination of fluorescent screen.
- Turn in spectrometer entrance aperture (1) and center (see Fig.).



Spectrometer entrance aperture	
Aperture position	Application
Aperture retracted	Fixed aperture effective
1st step Aperture 800µm dia.	Elastic/inelastic exposures with sheet-film camera ($\delta E \cong 23eV$)
2nd step Aperture 100 µm dia.	Recording of EELS spectra ($\delta E \cong 1.5eV$ at MAG 50,000x and beam current step 1)

- Switch to spectrum mode by pushing key IMAGE/SPEC (37) in field SPECTROMETER (activate SPEC).

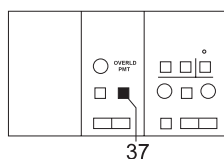
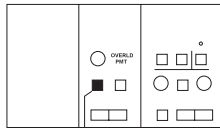


IMAGE SPEC





39

SHIFT FOCUS

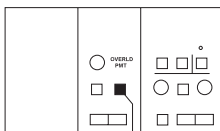


- Shift tip of spectrum caustic to center of fluorescent screen by pushing key SHIFT/FOCUS (39) (activate SHIFT).

- Turn in slit aperture (2 in Fig.) and with knobs align it with respect to caustic. Select slit width, it should not cut off the caustic figure tip or opposite edge.

SPECIAL NOTE:

Cutoff of the caustic tip will cause a dark spot in the image center (in IMAGE mode). Cutoff of at the edge will cause an almost circular cutoff of the format.



37

IMAGE SPEC



- Switch to IMAGE mode with key IMAGE/SPEC (37) in field SPECTROMETER.

SPECIAL NOTE:

The spectrum may shift with respect to the slit when the magnification is changed or in case of long-term thermal drift. The resulting cutoff must be corrected with the key SHIFT (39)!

4.7.2

Contrast tuning of thick specimens



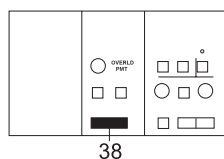
SPECIAL NOTE:

Always use the 30µm single hole objective lens aperture for thick specimens!

Thick objects will often display great differences in mass thickness.

If objects are very thick, the intensity of the energy loss electrons is higher (brighter image) than that of the zero loss electrons.

It may be of advantage in both cases to use selected inelastically scattered electrons for imaging.



Electron-spectroscopic imaging at maximum brightness

- Adjust for *elastic imaging* (see section 4.12.1).
- Vary ΔE value with the double key ENERGY LOSS (38) until the shortest exposure time is displayed.

Brightness compensation of objects with great differences in mass thickness (contrast tuning)

- Vary ΔE setting with the double key ENERGY LOSS (38) until the adjustment of the intensities in the areas of great and small mass thickness is optimized for maximum information.

4.7.3

Electron-spectroscopic imaging of thin specimens

Electron-spectroscopic imaging can be applied even to exceptionally thin, low-contrast specimens. The method requires very thin specimens which should be mounted on the specimen grid without carrier film. Inelastically scattered electrons are imaged.

Other than thick specimens, inelastically imaged thin specimens produce darkfield images.

Ideally thin specimens cause contrast reversal from the brightfield to the darkfield image already at approx. 20 eV. If specimens are thicker, the contrast reversal will occur only at higher energy losses. The higher the energy loss the higher contrast and resolution and the lower the brightness. Which will result in longer exposure times.

The image contrast depends on the elements present in the object and on the adjusted energy loss (ΔE).

ΔE values between 150 eV and 250 eV will produce high-contrast images, e.g. of biological objects.

The contrast becomes poorer above 280eV, depending on the carbon content of the object (absorption constant of carbon $C_K = 284\text{eV}$, carbon content of embedding resin approx. 60%).

4.7.4 Element-spectroscopic imaging

To visualize specific elements, choose ΔE values above the element-specific absorption edges.

One or several images below the corresponding absorption edge are also required for net elemental maps. Processing by the optional image processing system is possible.

Requirements:

- Object in beam path.
- Basic alignment as for elastic imaging.

Procedure:

- Search object spot at low magnifications.
- Turn in objective lens aperture diaphragm 30, 60 or 90 μm .



SPECIAL NOTE:

Use 30 μm aperture for sensitive objects, which reduces, however, the image intensity, especially for settings with higher ΔE .

- Adjust for 8,000x magnification.
- Exactly center objective lens aperture.
- Select magnification you want.
- Select ΔE value in menu ΔE (see section 3.10).
- Object focusing:
 - either: on small fluorescent screen in *low loss* range (approx. 50 - 80eV)
 - or: on TV camera/monitor before carbon edge (approx. 250eV)
- Brightness adjustment by increasing beam current and using the condenser.
- Expose (see Camera operation, section 4.15).



SPECIAL NOTE:

Kodak sheetfilm SO 163 is especially recommended for ESI imaging.

4.8 Brightfield / darkfield imaging

4.8.1 Brightfield imaging

The image is produced by unscattered electrons or electrons scattered under small angles which pass through the objective lens aperture. The contrast is defined by electrons which are scattered under larger angles and masked out by the objective lens aperture diaphragm.

Electrons in inelastic interaction with the specimen are scattered only under small angles, are therefore not trapped by the objective lens aperture and result in poorer image contrast (global imaging). Adjusting the omega filter to the elastic peak eliminates these electrons and noticeably improves the contrast (elastic imaging).

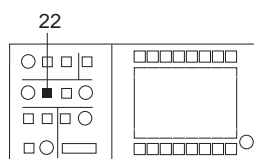
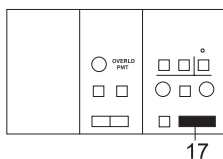
Important to obtain a satisfactory brightfield image:

- Exactly centered objective lens aperture.
- Beam incidence exactly parallel to the optical axis.

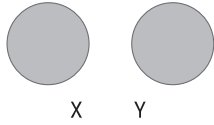
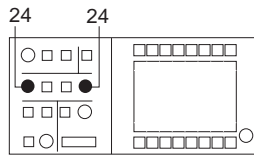
If the beam incidence is exactly adjusted, the image should not move when changing the high voltage.

Adjustment of straight beam incidence with high-voltage wobbler:

- Center high-contrast image detail to index point.
- Adjust for 31,500x magnification with double key MAGNIFICATION (17).
- Adjust for illumination TILT with key TILT/SHIFT (22) in field ILLUMINATION.
- Call menu PARAMETERS with softkey PAR of main menu.
- Push softkey FOCUS PAR.



WOBBLE
OBJ.FOC.



WOBBLE
OBJ.FOC.

- Objective lens focus wobbling: push softkey WOBBLE OBJ. FOC..
Key field highlighted.
- Adjust encoders X and Y (24) in field ILLUMINATION until the observed object feature stands still.
- Deactivate *wobbling* with key WOBBLE OBJ. FOC..

4.8.2

Darkfield imaging

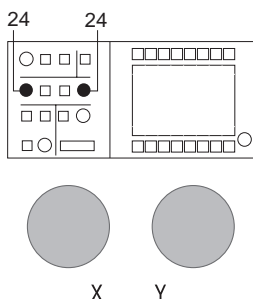
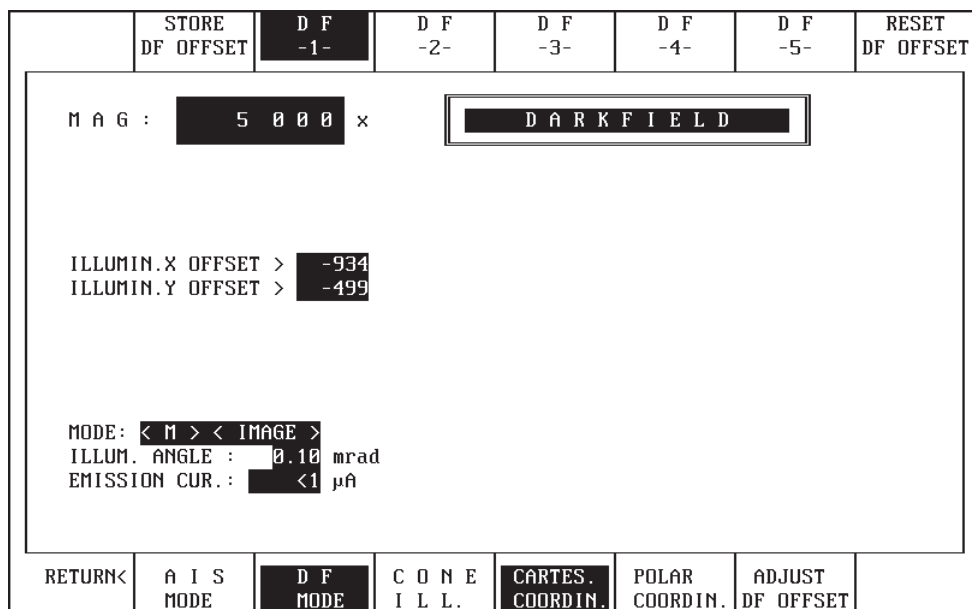
Darkfield images are produced by diffracted electrons or electrons scattered under large angles.

To produce the darkfield image the beam is tilted by the deflecting coils of the Scan System above the specimen (function ILLUMINATION TILT).

Here too, elastic filtering improves the image contrast (see also section 4.13.1 Brightfield imaging).

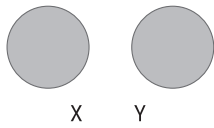
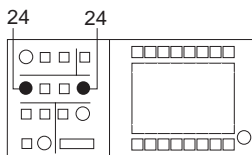
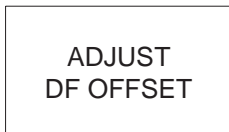
Procedure

- Push key PAR in main menu.
- Push key DF in menu PARAMETERS (call menu DARKFIELD).



- If specimens are amorphous select beam incidence with encoders X and Y (24) in field ILLUMINATION so that the primary beam is masked out by the objective lens aperture.
- Crystalline specimens are adjusted in diffraction mode. The diffraction image is shifted so that the desired diffraction reflex lies in the center of the aperture.

e.g.



- Center selected specimen detail to index point (specimen shift).
- Activate DIFFR.
- Retract objective lens aperture.
- Center diffraction image exactly to index point (image shift).
- Call DF menu, select storage key 1 - 5.

- Activate ADJUST DF OFFSET.

- Switch to DF (key DF MODE).
- Activate CARTES. COORDIN. in the darkfield menu.

- Center selected diffraction reflex exactly to index point with encoders ILL. X and Y (24) in field ILLUMINATION.

- Push key STORE DF OFFSET, the value is stored in the selected memory.

- Select further reflexes accordingly.
Deactivate DF (push key DF MODE again).
- Insert and center objective lens aperture.
- Switch to IMAGE.
Change between brightfield and darkfield with key DF is possible.

Advantages of the menu DARKFIELD:
Change between brightfield and darkfield without realignment.
The corresponding darkfield offset is displayed on the monitor and can be stored or recalled.

4.9 Diffraction

If inelastically scattered electrons are masked out with the slit aperture the contrast is significantly improved and diffraction diagrams can be quantitatively evaluated.

All diffraction methods in filter mode are possible in the LEO 912 OMEGA.

Spectrometer aberrations may cause asymmetrical vignetting of the diffraction patterns with short camera lengths $CL < 900\text{mm}$) and small slit width. Exact centration of the slit aperture and the elastically filtered diffraction image (IMAGE SHIFT) is, therefore, necessary. When centering the slit aperture in DIFF mode the vignetting of the diffraction image should be (mirror)symmetrical.

Centering of slit aperture and diffraction image

- Remove condenser aperture, objective lens aperture and specimen.
- Select ILL. SPOT mode.
- Adjust for 10nm spot size.
- Select DIFF imaging mode.
- Adjust for 290mm camera length.
- Turn in slit aperture and adjust illumination using the Y shift of the slit drive.
- Select IMAGE SHIFT mode.
- Center elastic brightfield with encoders IMAGE X and Y.



SPECIAL NOTE:

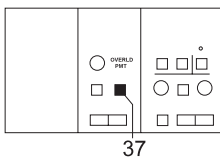
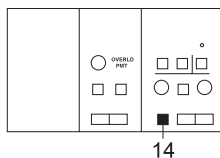
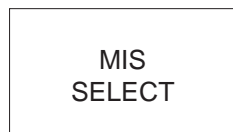
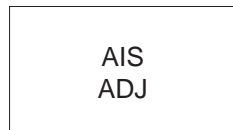
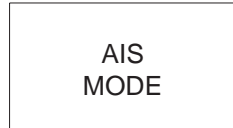
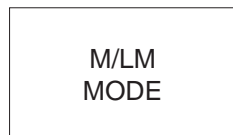
With an exactly aligned instrument and calibrated image shift the elastic brightfield will be in the center of the fluorescent screen and the diffraction spot is centered (if the direction of incidence is correct).

The camera length ranges M and LA correspond with the magnification ranges M and LM. The camera length range M ranges from 290mm to 7200mm, the LA (Low Angle) range from 10m to 800m. To switch between the two ranges use the key M / LM MODE of the main menu.

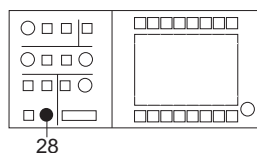
4.9.1

Selected-area diffraction with AIS apertures in M mode

Specimen areas chosen for diffraction with diameters from 16 to 1 μ m



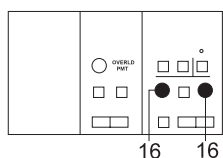
- Adjust magnification range M with key M / LM MODE.
- Activate AIS mode with key AIS MODE.
- Center small (37 μ m) AIS aperture exactly to spot on index point.
- Call menu PARAMETERS with key PAR.
- Call menu AIS ADJUST with key AIS ADJ.
- Activate MIS mode with key MIS MODE.
- Select aperture for specimen area chosen for diffraction with key MIS SELECT.
- Activate image mode with key DIFF (14).
- Retract objective lens aperture.
- Switch to spectrum mode (37).
- Center slit aperture. Only zero loss electrons should pass the slit aperture.
- Switch to image mode (37) and focus the filtered diffraction image with encoder OBJECTIVE in the field FOCUS.



28



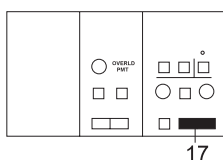
OBJECTIVE



16 16



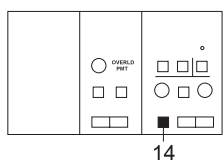
X Y



17



MAGNIFICATION



14

IMAGE DIFF



- Focus diffraction image with encoder OBJECTIVE (28) in field FOCUS.

- Compensate astigmatism with encoders X and Y (16) in field IMAGE.

- Select camera length with double key MAGNIFICATION (17).

Specimen areas chosen for diffraction with diameters of $\geq 0.2\mu\text{m}$

- Deactivate AIS mode.
- Precenter small condenser aperture with diameter from 5 to 30 μm for the magnification you want to use (aperture generally in position 1).
- Retract condenser aperture.
- Center specimen area chosen for diffraction to index point.
- Turn in single-hole condenser aperture with diameter from 5 to 30 μm and center (5 μm aperture corresponds to an area of 0.2 μm).
- Change to diffraction by pushing key DIFF (14) in field IMAGE.
- Focus diffraction image.
- Center slit aperture.



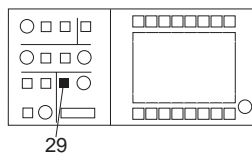
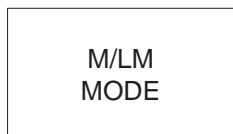
SPECIAL NOTE:

You may also use a projector lens aperture to select specimen areas for diffraction $\leq 1\mu\text{m}$.

4.9.2

Microbeam diffraction (Nanoprobe)

Diffraction specimen area between 1.6nm and 100nm diameter, SPOT illumination.



TEM SPOT



ILL MODE

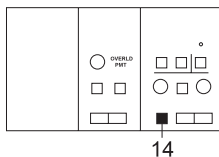
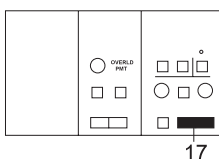


IMAGE DIFF



SPECIAL NOTE:

The size of the condenser aperture defines the diameter of the disk (the $5\mu\text{m}$ condenser aperture corresponds to $2\mu\text{m}$ diameter of the diffraction spot).



MAGNIFICATION

- Adjust magnification range M with key M/LM MODE.
- Set specimen feature to index point.
- Select condenser aperture with max. $5\mu\text{m}$ hole diameter.
- Change to SPOT mode with key SPOT (29) in field BRIGHTNESS.
- Adjust spot size.
- Switch to diffraction with key DIFF (14) in field IMAGE (diffraction reflexes appear as small disks).
- Center slit aperture.

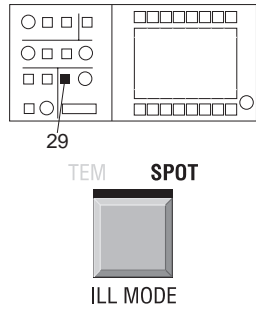
- Select camera length with double key MAGNIFICATION (17).

Version 3.20

4.9.3

Convergent Beam Electron Diffraction (CBED)

Diffraction specimen area between 1.6 nm and 100 nm diameter SPOT illumination

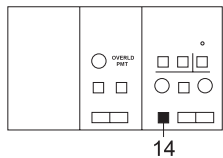


29

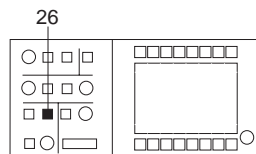
TEM SPOT



ILL MODE



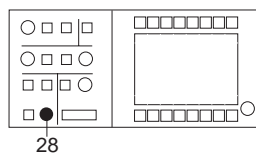
14



26



CALIBRATE

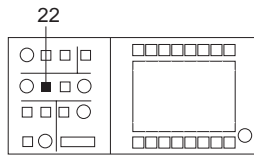


28



OBJECTIVE

- Adjust magnification range M with key M / LM MODE.
- Select small condenser aperture with max. 75µm hole diameter.
- Adjust for SPOT illumination with key SPOT in field BRIGHTNESS.
- Activate IMAGE mode with key IMAGE (14).
- Calibrate objective lens to eucentric axis with key CALIBRATE (26) in field FOCUS.
- Through-focus image on fluorescent screen with encoder OBJECTIVE (28) in field FOCUS.



TILT SHIFT

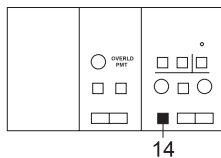
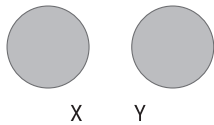
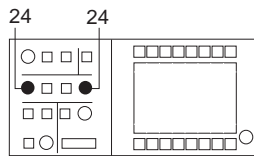
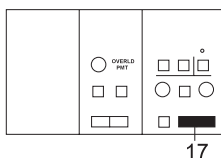


IMAGE DIFF



MAGNIFICATION



- Select SHIFT illumination (22).

- Shift spot to selected specimen spot with encoders X and Y in field ILLUMINATION.

- Switch to diffraction with key DIFF (14) in field IMAGE.

- Select camera length with double key MAGNIFICATION (17).

- Center slit aperture.

Special note:

The diameter of a diffraction disk is defined by the size of the condenser aperture (37.5 μm condenser aperture Δ 16 μm). The diameter of the diffraction disk is slightly variable by varying the excitation of the third condenser and the objective lens focus.

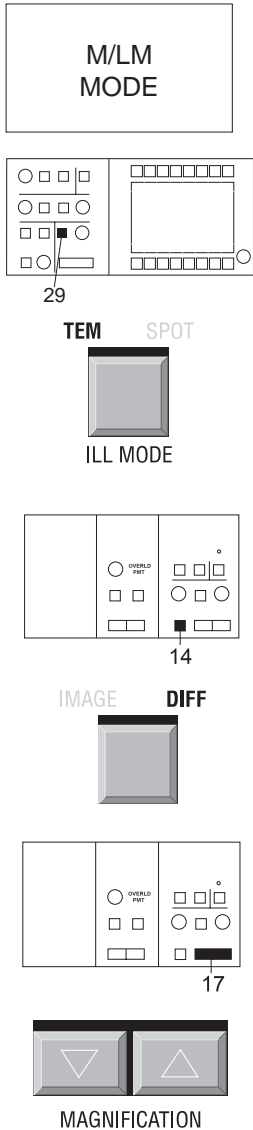
4.9.4

Low-angle diffraction

The diffracted specimen area is defined by the condenser aperture with 0.2µm and 100µm diameter (30 µm Δ 70µm). Low objective lens excitation.

For this diffraction mode

- Adjust magnification range LM with key M / LM MODE.
- Activate TEM illumination mode (29).
- Select area for diffraction with condenser aperture.
- Switch to diffraction with key DIFF (14) in field IMAGE.
- Select camera length with double key MAGNIFICATION (17).
- Focus diffraction image with encoder OBJECTIVE.
- Center slit aperture.

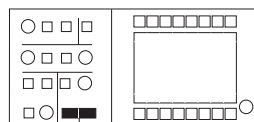


4.10

Photography

4.10.1

Single exposures



31



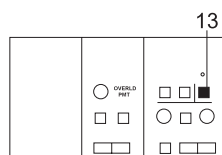
ILL APERTURE / SPOT SIZE

EDIT
FREE INP.

- Set image brightness to suitable value with double key ILL. APERTURE / SPOT SIZE (31). Observe displayed exposure time (otherwise error message from camera control).
- Adjust specimen detail of interest to film format using the 4 corners on the large fluorescent screen.
- Enter free text for imprint on the negative in the menu SHEET FILM CAM.
- Push key EDIT FREE INP. and enter desired comments for imprint (option in menu SHEET FILM CAM).
- Focus specimen detail.
Use function *Minimum Dose Focusing* (MDF), if necessary (see also next section 3.4.9). If adjusted in the menu FOCUS PARAM. the defocus parameters are adjusted by the computer during exposure.

SPECIAL NOTE:

No defocus should be adjusted for exposures with inelastically scattered electrons ($\delta E > 0$), to prevent unsharp images.



13



EXPOSURE

- Release **single exposures** with key EXPOSURE (13) on left control panel.
 - Both fluorescent screens are raised.
 - The exposure time is displayed by an inset.
 - Data and image are automatically exposed.
 - The inset disappears when the fluorescent screens are lowered.
 - The instrument is ready for the next exposure.

Diffraction images are generally exposed using manually preset exposure times after estimation (e.g. $1/10$ of the value displayed by the SMALL SCREEN exposure meter). With the option EXPOSURE SERIES exposures are possible under different exposure conditions.

4.10.2 Camera adjustment

The adjustment of the sheet-film camera or the optional 35mm camera is program-controlled by the menus SHEET FILM CAM. / 35MM-CAMERA and CAMERA SETTING. The following parameters are defined:

- Density of data imprint and image
- Film supply
- Exposure meter (small fluorescent screen or electron collector in sheet-film camera)
- Exposure time
- Exposure mode (fixed time or automatic)

C A M S E T >	E X P S E R >	BEAM BLANKER	M I S MODE	M I S SELECT	EDIT USER/NO	EDIT FREE INP.	EDIT COMMENT
<p>M A G : 5 0 0 0 x S H E E T F I L M C A M .</p> <p>STATUS: OK</p> <p>FILM DATA: CZ 291297 M 5000<2.90µm> Nr.7411 U120- 0 -82.0°</p> <p>COMMENT: </p> <p>FILM SUPPLY: 02 EXPOSURE METER: CAMERA COLLECTOR</p> <p>FILM DENSITY B: 3.6 e1/µm² EXPOSURE TIME : AUTOMATIC sec</p> <p>DATA DENSITY B: 15 FIXED 2.4 sec</p>							
RETURN<	FIX.TIME DOWN	FIX.TIME U P	EDIT FIX.TIME	MULTI EXPOSURE	EXP.TIME MODE	DENS A/ DENS B	D F TILT

CAM SET

- Call menu CAM SETTING with key CAM SET.

P L / 35 MM			EDIT FILM SUP.	EDIT USER/NO	CLEAR CAM. FILE	AUTO PRINT	AUTO FILE
M A G : 2 0 0 0 0 x			C A M S E T T I N G				
			S H E E T F I L M C A M.				
USE THICK PLATE HOLDER							
Σ EXPOSURE: 000000							
FILM DATA:			EZ 011297 M 20000<0.73µm> Liposomes frozen U120- 0 0nm				
FILM DENSITY A: 1.5 e1/µm ²							
DATA DENSITY A: 6							
FILM DENSITY B: 3.6 e1/µm ²							
DATA DENSITY B: 15							
FILM SUPPLY: 02			EXPOSURE METER: CAMERA COLLECTOR				
			DATE: 01.12.1997				
			TIME: 20.16.23				
RETURN<	SELECT I/δf/θ	EDIT DENS A	EDIT DENS B		SELECT EXP.METER	EDIT TIME	EDIT DATE

EDIT FILM SUP.

DENS A/
DENS B



- Enter film supply with key EDIT FILM SUP.
- Preselect film sensitivity with key DENS A / DENS B.
 - Each setting includes a data density and a film density.
 - Enter the sensitivities:

SPECIAL NOTE:

The data sheets of most EM film manufacturers specify the slope of the density curve (electronic speed) of the electron sensitivity. In the linear region of the curve (optical density 1) its reciprocal value can be read directly as exposure e-/µm² and entered in the menu.

Example:

Electron sensitivity 2 ⇒ 0.5 e-/µm² exposure means an average of 0.5 e-/µm² on a surface of 1µm² of the negative.

Sensitivity of recommended films see table on next page.

Sensitivity of EM films (sheet-film camera)

Application	Film	Development	Film density Exposure D = 1 el/ μm^2	Data density Exposure D = 1 el/ μm^2
Brightfield $\Delta E = 0\text{eV}$ Darkfield $\Delta E = 0\text{eV}$	Kodak S0163 3 ¹ / ₄ x 4 in.	Kodak D 19 1+2, 4' 20 °C	approx. 1.2	approx. 3.0
Brightfield $\Delta E = 0\text{eV}$ with high re-enlarge- ment	Kodak 4489 3 ¹ / ₄ x 4 in.	Kodak D 19 1+2, 4' 20 °C	approx. 3.0	approx. 15.0
ESI $\Delta E > 0\text{eV}$ low and medium EM magnification	Kodak S0163 3 ¹ / ₄ x 4 in.	Kodak D 19 konc., 12' 20 °C	approx. 0.6	approx. 3.0
<p>SPECIAL NOTE: The sensitivity of the film will be higher with a developer combination of 9 parts Kodak D 19 1+2 and 1 part Röntogen, 4' at 20 °C. The density values can be reduced by the factor 2.</p> <p>Explanation of development specification:</p> <p style="text-align: center;">Kodak D19 1+2, 4' 20 °C</p> <div style="display: flex; justify-content: space-around;"> <div style="text-align: left;"> <p>Developer ———</p> <p>Dilution ———</p> <p>1 part developer 2 parts water</p> </div> <div style="text-align: right;"> <p>Developer temperature</p> <p>Development time</p> </div> </div> <p>!C5,5,0,255,255,255</p> <p style="text-align: right;">\$</p>				

EDIT
FIX TIME

FIX TIME
UP

and

FIX TIME
DOWN

AUTO
PRINT

AUTO
FILE

- Activate fixed or automatic exposure time with key EDIT FIX TIME.
 - In fixed-time mode define time with keys FIX TIME UP and DOWN.
 - Select exposure meter in automatic mode.
It is possible to switch between the electron collectors:
 - in small fluorescent screen (display: SMALL SCREEN).
 - directly under the negative in the camera (display: CAMERA COLLECTOR)
 - Automatic printout of data field can be activated with key AUTO PRINT in menu CAM SETTING.*
 - Automatic storage of data field text can be activated with key AUTO FILE in menu CAM SETTING.
- *) Required is the option printer interface!

4.10.3

Operation of sheet-film camera

4.10.3.1

Ventilation and pumpdown of camera chamber

The function is activated from the menu VACUUM with key VENT / EVAC CAM.

The same key is used for ventilation and pumpdown. The evacuated camera chamber is ventilated when the key is pushed, and the ventilated camera chamber evacuated.

- Push key VENT / EVAC CAM in the menu VAC.
 - Separating valve V3 closed.
 - Turbomolecular and rotary pumps switched off.
 - Viewing head and camera chamber flushed with predried nitrogen.

4.10.3.2

Loading and removing films (general)

Three types of cassettes are available to load film material in the sheet-film camera (Fig. 4-8).

- Sheet-film cassettes 3¹/₂ x 4 inch (1), 1.5mm thick
- Glass plate cassettes 3¹/₂ x 4 inch (2), 3mm thick
- Adapter cassettes for glass plate cassettes for the film format 6.5 x 9cm (3), 3mm thick

The cassettes are accommodated in a magazine (4). The magazine accepts 40 sheet-film or 20 glass plate or adapter cassettes.

After ventilation of the sheet-film camera the front door is opened and the magazine loaded from the front in the upper part of the sheet-film camera chamber. The safety springs of the magazine are unlocked when it is slid in. The cassettes drop on the upper transport plane. Each bottommost cassette is ready for exposure.

Cassettes with exposed films are collected in collector (5) in the sheet-film camera chamber, which can be unloaded from the front.

Light-tight container (6) is used for the transport of a magazine or cassettes with exposed or unexposed films.

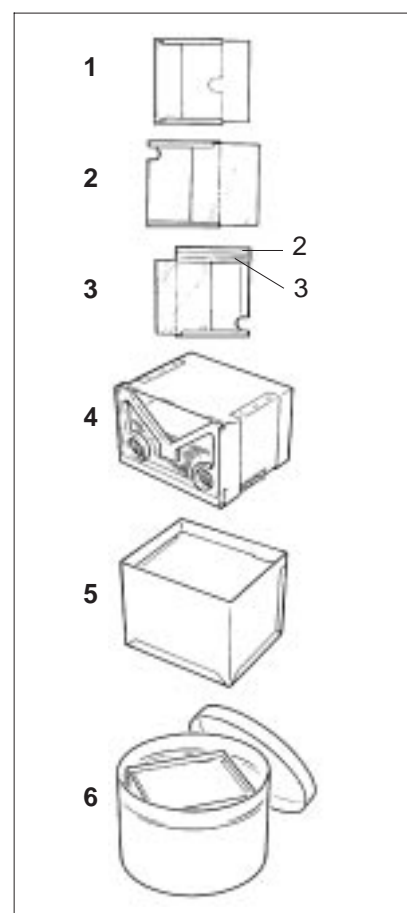


Fig. 4-8: Loading and unloading films

**SPECIAL NOTE:**

Load only predried films!

If the films are not or poorly dried preset breakover points are not attained in time. The vacuum system issues an error message.

Predry cassettes with unexposed films in a desiccator flushed with nitrogen gas. Only then will you achieve short pumpdown times independently of the humidity of the air.

4.10.3.3**Adapting the sheet-film camera to the cassette type.**

For the available cassette types see section 4.15.3.2.

For the sheet-film cassette 3¹/₂ x 4 inch (1, Fig. 4-8):

- Slide reduction insert 34 11 40-8011 horizontally all the way into the camera (position behind magazine and collector above transport carriage).

For glass plate or adapter cassettes (3mm thick) (2 or 3, Fig. 4-8):

- Remove reduction insert from the camera when you use thick cassettes.

4.10.3.4**Loading cassettes and sheet-film camera**

The steps described below must be carried out in ruby light.

- Ventilate camera chamber as described in section 4.15.3.1.

Loading 3¹/₄ x 4 inch (8.2 x 10.2cm) sheet film in sheet-film cassette (1) (1.5mm thick)

- Hold the cassette so that the large grip groove is on the right side.
- Slide in film with the emulsion face up as far as it will go. If cassettes are not provided with a stop, the film should be flush with the outer edge.

Loading 3¹/₂ x 4 inch plates or sheet film in glass plate cassette (2)

- Slide 3¹/₂ x 4 inch (8.2 x 10.2cm) plates or sheet film with the emulsion face up all the way into glass plate cassette (2) (3mm thick).

Loading 2¹/₂ x 3¹/₂ inch (6.5 x 9.0cm) plates or sheet film

- Slide adapter (3) with large grip groove all the way to the right into glass plate cassette (2). Slide plates or sheet film into adapter.

Loading cassettes in plate magazine and camera

The cassettes are loaded in plate magazine (4) 34 11 40-8002 which is slid into the camera from the front. The grip groove of the cassettes should be at rear.

- Press together specs (4.1) in magazine (4) (Fig. 4-9).
- Hinge up specs.
- Slide in sheet-film cassette.
- Hinge down specs.
- Slide magazine (4) into open camera at top (Fig. 4-10).
- Slide collector (5) into camera at bottom.
- Close camera and pump down camera chamber as described in section 4.15.3.1.

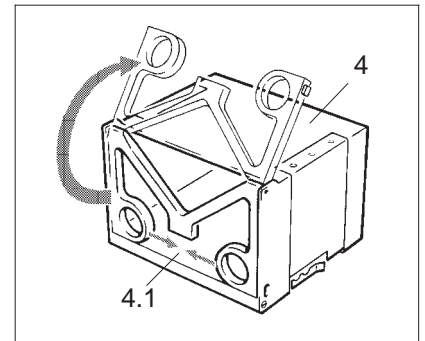


Fig. 4-9: Loading the magazine

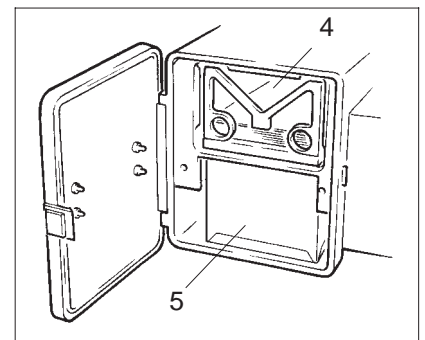


Fig. 4-10: Loading the sheet-film camera



SPECIAL NOTE:

When the magazine is slid into the camera it opens automatically and the sheet-film cassettes drop into transport position.

4.10.3.5**Removal of exposed sheet film (unloading the camera)**

The exposed cassettes drop into receiver (4) 34 11 40-8005 accommodated in front at the camera chamber bottom.

- Ventilate camera chamber as described in section 4.15.3.1.
- Open camera and take out receiver (4, Fig. 4-10).
- Close camera and pump down camera chamber as described in section 4.15.3.1.

To remove unexposed film from the camera (in ruby light):

- Ventilate camera and open.
- Take out receiver (4).
- Lift cassettes in magazine by hand from below approx. 10mm and pull magazine forward. This closes the locking spring of the magazine and the content can be taken out.

4.10.3.6**Sheet-film transport outside the camera**

A light-tight transport container (6) 34 11 40-8007 is supplied to transport films from the instrument to the darkroom in plate magazine or receiver.

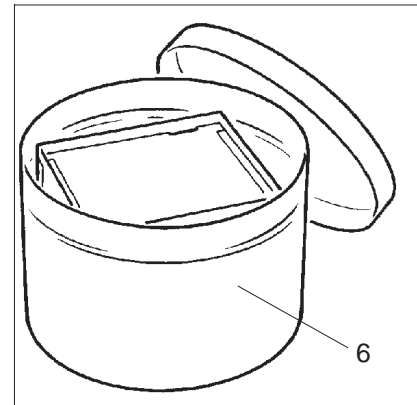


Fig. 4-11: Transport container

4.10.3.7**Desiccator**

A desiccator 34 57 68-0000 which can be flushed with nitrogen is recommended for pre-drying of films.

Recommended procedure:

- Degas filled magazine together with transport container without lid,
- flush desiccator with nitrogen,
- close transport container, and
- in dry nitrogen atmosphere bring films to the camera and load instantly.

4.11

Backup messages

After a certain number of LEO 912 OMEGA performed system starts are ascertained, the following message is displayed:

!! IT IS TIME TO BACKUP ALL DATA !!
ON A FLOPPY DISKETTE

!! CHECK THE AIR FILTER !!
IN THE POWER SUPPLY

PRESS ANY KEY TO CONTINUE

Data backup:

- Operate any key to call the START menu.
- Insert backup floppy.
- Push softkey BACKUP ALL: data backup on floppy disk.
See also section 1.2.10 *Memory/data management* (Fig 1-36)
- Push START key and continue normal instrument operation.

BACKUP
ALL

START

**SPECIAL NOTE:**

The message STORE SYSTEM DATA SET !!! is displayed when the LEO 912 OMEGA program is quitted with EXIT. The message means that a backup was made.

**SPECIAL NOTE:**

The number of system starts requiring backup can be preset by the menu UTILITIES (variable START UP TIMES). The variable field is selected with softkey EDIT BAC. CALL (see section 3.4.6).

4.12 Storage of user data

4.12.1 Storage on hard disk

EXIT

USER

- Automatic storage of the system data after leaving the main menu by EXIT. The same setting is reactivated with the next instrument turn-on, provided no other user data are loaded in the START menu.
 - Push softkey EXIT in the main menu.
 - Quit the inquiry with PROCEED.
 - The actual instrument setting is stored on hard disk. Display on monitor: STORING SYSTEM DATA.
 - LEDs on operating panels go out.
 - The START menu is displayed after a few seconds.

- Storage of the system data by menu USER.
 - Call the menu PARAMETERS with softkey PAR and then USER.

EDIT USER NAME	STORE USER PAR.			USER 1 Test	USER 2	USER 3	USER 4
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">U S E R</div>							
RETURN<	RECALL USER PAR.			USER 5	USER 6	USER 7	USER 8

STORE
USER PAR.

RECALL
USER PAR.

- Click on 1 of the 8 users and edit the user name.
- Click on STORE USER PAR. The system data are stored under the activated user position.
- For loading click on RECALL USER PAR. The activated user data are loaded into the RAM memory.

4.12.2

STORE
USER DTA.

Storage on floppy

- Insert a floppy disk into the disk drive below the key switch.
- Push softkey STORE USER DTA. of START menu.
- Enter USER number (1 ... 8).
- The MS-DOS level is displayed on the monitor:

```

Creating necessary Directory's if not exist

C:\EM>COPY C:\EM\DATA\EM_U1.DTA A:\EM\DATA /U
1 Datei(en) kopiert

C:\EM>PAUSE
Weiter mit beliebiger Taste . . .

```

- The selected user data set is copied from the hard disk on the floppy disk.

4.13

Loading user data

4.13.1

Loading user data from a floppy disk

RECALL
USER DTA.

- Insert floppy with user data into disk drive.
- Push softkey RECALL USER DTA. of START menu.
- Inquiry for USER 1 ... 8 is displayed.
- Enter user number.
- Terminate input with RETURN.
- USER is loaded on selected position of hard disk.

See also section 11.2.10 Memory/data management (Fig. 1-36)..



SSPECIAL NOTE:

The position is part of the file name. If the file copy requires another position on the hard disk, the file must be renamed in MS-DOS, e.g. from USER4 to USER6.

4.13.2

Loading user data from hard disk

USER 1

RECALL
USER PAR.

START



- Call menu PARAMETERS with softkey PAR and then USER
- Push softkey of desired user, e.g. USER1.

- Call user data with softkey RECALL USER PAR.
The LEO 912 program returns to START menu. The user data are loaded from the hard disk.

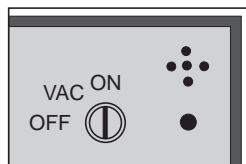
- Call main menu with softkey START.
The main menu containing the data of the selected user is displayed on the control monitor.
The LEO 912 OMEGA is automatically set to the status displayed on th control monitor.

For the detailed description of the USER menu see section 3.4.2.

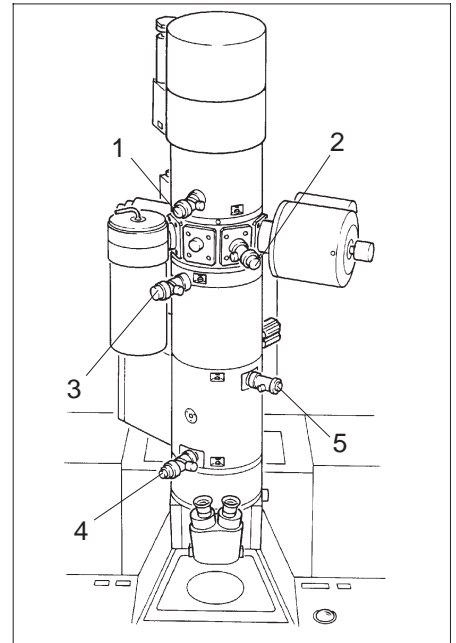
4.14 EM system turn-OFF

START

EXIT



- **All apertures might be retracted (1-5)** by turning knurled knob of aperture drive counterclockwise to the stop.
- **Return to main menu.**
Depending on the activated operating menu push softkey RETURN once or repeatedly until the main menu is displayed.
- **User data stored on hard disk.**
The instrument setting can be stored on 1 of the 8 user positions, and later on recalled from this position. (See section 4.17.1).



- **Return to START menu.**
Push key EXIT in main menu.
 - The user is asked whether he wants to exit from main menu: EXIT TO START MENU: PROCEED/CANCEL. Confirm PROCEED.
 - The actual instrument setting is stored on hard disk. The same setting is reactivated with the next instrument turn-on, provided no other user data are loaded in the START menu.
Display on the monitor: STORING SYSTEM DATA.
 - LEDs on the operating panel go out.
 - The START menu is displayed after a few seconds.
 - In the START menu the instrument setting can be stored on a floppy disk.
- For further details see section 4.17.2.

- **Turn key switch from ON to VAC or OFF.**
 - In VAC position the complete vacuum system continues working.
 - In OFF position the Turbo pump is partly ventilated. The rotary pump is switched after a few seconds. The IGP pump(s) continue(s) working.

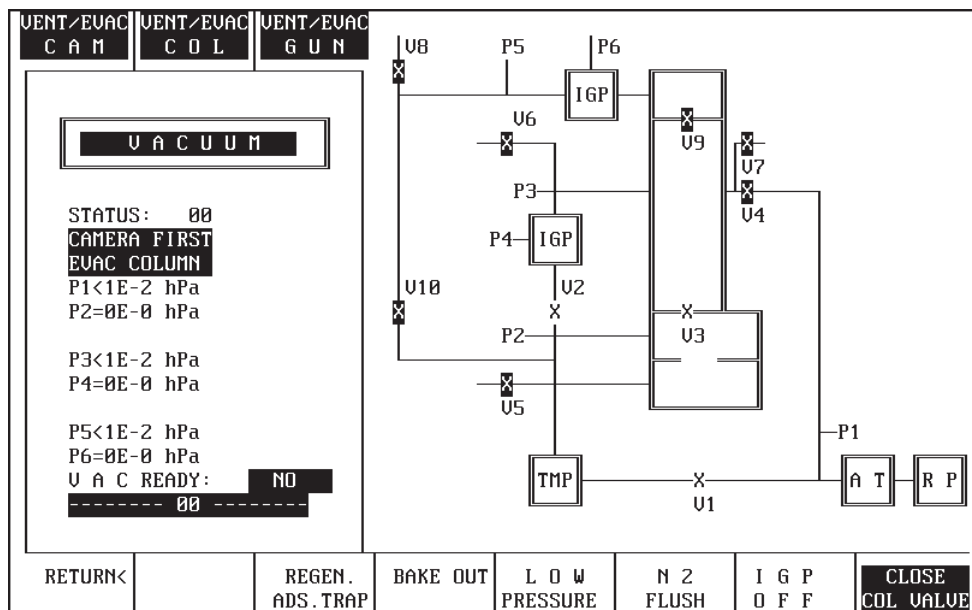
4.15 Status messages

4.15.1 Status messages of vacuum system

Status messages of the vacuum system are displayed on the control monitor in the menu VACUUM.

SPECIAL NOTE:

Displayed is the vacuum system with the option “2nd ion getter pump”.



SPECIAL NOTE:

A compressed-air supply of 6bar is required for all operating modes of the vacuum system. If compressed air is missing or drops below the indicated value the VAC menu displays the message “Air pressure too low”.

The displayed error must be confirmed when the operating conditions are restored! Confirmation by pushing spacebar. If no success, reset vacuum with the hidden reset button on the left panel.

If the instrument is only intermittently switched off with the key switch and switched back on within 5 seconds it is not partially ventilated. The pump control immediately starts pumpdown. The vacuum go-ahead is restored after a few seconds.

Status	Message
01 AIR PRESSURE TOO LOW	Air pressure below 6bar
02 PREVACUUM TOO HIGH	Vacuum of 1×10^{-1} hPa in pre-vacuum hose not obtained in 60 seconds during pumpdown.
03 PREVACUUM TOO HIGH	Vacuum of 1×10^{-1} hPa in column not obtained in 10 minutes during pumpdown.
04 TURBOSPEED TOO LOW	During pumpdown the turbomolecular pump does not attain 80% of nominal speed in 4 minutes.
05 TURBOSPEED TOO LOW	<ul style="list-style-type: none"> <li>– In continuous operation (running for more than 4 min.) speed of turbomolecular pump drops to less than 80% of nominal speed. <li>– In continuous operation prevacuum in camera chamber (VVK) increases to more than 1×10^{-1} hPa.
06 TURBO ELECTRONICS OFF	Error message from thermoelement TCP 120 (contactor K2 dropped off).
07 PENNING TUBE DEFECT	High vacuum measured on IKR 20 less than 0.1V, i.e. tube defective or broken circuit.
08 IGP1 DEFECT	Current measured on IGP1 ion getter pump too low (broken circuit).
09 TURBOVAC TOO HIGH	In continuous operation high vacuum increases to more than 4×10^{-4} hPa.
10 TURBOVAC TOO HIGH	High vacuum of 5×10^{-4} hPa not obtained in 20 minutes.
11 IGP1 VACUUM TOO HIGH	In continuous operation IGP1 vacuum value increases to more than 1×10^{-5} hPa.

12 WAIT! IGP1 RESTART	<p>IGP1 ion getter pump switched off because</p> <ul style="list-style-type: none">– pressure raises to more than 1×10^{-2} hPa or– pressure raises to 1×10^{-5} hPa within 10 minutes.
13 PREVACUUM TOO HIGH	<p>In the start phase camera chamber pre-vacuum (VVK) of 1×10^{-1} hPa not attained in 10 minutes.</p>
14 TURBOSPEED TOO LOW	<p>In the start phase turbomolecular pump does not attain 80% of the nominal speed in 10 minutes.</p>
15 TURBOVAC TOO HIGH	<p>In the start phase high vacuum of 5×10^{-4} hPa not attained in 10 minutes.</p>
16 WAIT! IGP1 RESTART	<p>IGP1 ion getter pump is switched off for 2 min. to cool down if an IGP vacuum of 2×10^{-5} hPa was not attained in 3 or 6 min. (depending on the high vacuum).</p>
17 IGP1 VAC NOT O.K.	<p>IGP1 monitoring records a pressure rise in the column to more than 1×10^{-1} hPa.</p>
18 IGP1 VAC NOT O.K.	<p>IGP1 monitoring records a pressure rise in the column to more than 1×10^{-5} hPa in 10 minutes.</p>
19 IGP1 ELECTRIC-UNIT OFF	<p>IGP1 monitoring records a pressure of less than 1×10^{-6} hPa (broken circuit).</p>
20 PREVACUUM TOO HIGH	<p>TMP monitoring records increase of VVK value to 1×10^{-1} hPa in 4 minutes.</p>
21 TURBOSPEED TOO LOW	<p>TMP monitoring records speed drop to less than 80% of the nominal speed in 4 minutes.</p>
22 TURBOVAC TOO HIGH	<p>TMP monitoring records increase of high vacuum to 5×10^{-4} hPa in 4 minutes.</p>

23 REG. OF AD-SORPT. TRAP	Regeneration of adsorption trap activated.
24 PREVACUUM TOO HIGH	Camera chamber prevacuum of 1×10^{-1} hPa not attained in 50 seconds after unpermissible airlock operation.
25 PREVACUUM TOO HIGH	Camera chamber prevacuum of 1×10^{-2} hPa not attained in 60 seconds in airlock prepump phase.
26 V3 NOT CLOSED	Valve V3 not completely closed.
27 V3 NOT OPEN	Valve V3 not completely open.
28 WATER FLOW TOO LOW	Cooling water flow too low.
29 CATHODE HEAD NOT REPLACED	Gun not (completely) lowered.
30 WAIT! IGP1 RE-START	Restart of IGP1 ion getter pump after vacuum breakdown in column due to lock-in/out.
31 VACUUM SYSTEM START	Vacuum system in start phase.
Additional status messages with option "2nd ion getter pump"	
32 PREVACUUM TOO HIGH	Prevacuum of 1×10^{-2} hPa in gun not attained in 10 minutes.
33 TURBO SPEED TOO HIGH	80% nominal speed of turbomolecular pump for pumpdown of gun not attained in 10 minutes.
34 TURBO VAC TOO HIGH	During pumpdown of gun high vacuum of 5×10^{-4} hPa not attained in 10 minutes.

35 WAIT! IGP2 RESTART	IGP2 ion getter pump switched off to cool down if during pumpdown of gun and when V10 is closed a high vacuum of 2×10^{-5} hPa is not attained in 10 minutes (new pumpdown of gun).
36 GUN IGP1 DEFECT	Measured current of IGP1 ion getter pump too low (broken circuit).
37 GUN VACUUM TOO HIGH	In continuous operation IGP2 ion getter pump raises to more than 2×10^{-5} hPa.
38 WAIT! IGP2 RESTART	If in continuous operation a high vacuum of 2×10^{-5} hPa is not attained in 10 minutes, IGP2 is switched off to cool down. Restart of cyclical pumpdown of gun.
39 V9 NOT OPEN	Valve V9 not completely open (continuous operation).
40 V9 NOT CLOSED	Valve V9 not completely closed (switch-off mode).
41	Measured current of IGP2 ion getter pump too low (broken circuit).
42	High vacuum of IGP2 raises to more than 2×10^{-5} hPa in continuous operation.
43 V9 NOT CLOSED	Valve V9 not completely closed.
45 START IGP2 AND TURBO	The status display stops for 30s if during cyclical pumpdown of gun the high vacuum of the IGP2 ion getter pump raises to more than 2×10^{-5} hPa.
46 GUN AND COL VACUUM TOO HIGH	High vacua of IGP1 and IGP2 ion getter pumps above 2×10^{-5} hPa.
47 GUN DEFECT COL DEFECT	Circuit break of IGP1 and IGP2 ion getter pumps.

48 PREVAC GUN TOO HIGH	Prevacuum in gun during cyclical pumpdown above 1×10^{-2} hPa.
49 ONLY TURBO ACTIVE	During cyclical pumpdown of gun the turbopump pumps for 10 minutes until the prevacuum is less than 1×10^{-2} hPa.
50 V9 NOT OPEN	Valve V9 not completely open.
51 PREVACUUM COL HIGH	Prevacuum in column more than 1×10^{-1} hPa when gun and column are pumped down at the same time.

4.15.2 Error messages on EL display

The following error messages are displayed on the EL display and are self-explanatory. Some messages do not refer to genuine errors but are informative. Genuine errors, e.g. codes 0 or 2 must be remedied (e.g. faulty plug contact). Error messages are cleared by operating the spacer key of the keyboard or any menu key (the selected function is executed).

List of error messages on EL display

0	ERROR #:CHECK PRINTER
1	ERROR #:DATABUS ERROR
2	ERROR #:SERIAL COMMUNICATION ERROR
3	ERROR #:FOCUS WOBBLE IS ON
4	ERROR #:NEW MODE ONLY FROM MAINMENU
5	ERROR #:PLEASE SELECT IMAGE MODE
6	ERROR #:FRAME MATRIX ERROR
7	ERROR #:WRONG PARAM. FOR EXP. SERIES
8	ERROR #:DEFOCUS MODE MUST BE OFF
9	ERROR #:IN LENS PROGRAM 5 ... 8 ONLY
10	ERROR #:IN LENS PROGRAM 5 ... 8 ONLY
11	ERROR #:IN LENS PROGRAM 5 ... 8 ONLY
12	ERROR #:NO AIS IN LM-MODE
13	ERROR #:AIS IS OFF
14	ERROR #:NO DF IN LM-MODE
15	ERROR #:DF IS OFF
16	ERROR #:NO MDF IN LM-MODE
17	ERROR #:MDF IS OFF
18	MESSAGE #:PRINT EM-PARAMETER
19	MESSAGE #:PRINT CAMERADATA
20	ERROR #:EXPOSURE SERIES IS SELECT
21	ERROR #:IN MAG IMAGE MODE ONLY
22	ERROR #:IN FILE ACCESS
23	ERROR #:NOT ENOUGH MEMORY
100	ERROR #:OPTION NOT AVAILABLE
101	ERROR #:COMMAND NOT AVAILABLE

200 ERROR #:NO CONNECTION TO VAC-SYSTEM
201 ERROR #:TIMEOUT ON VAC-INTERFACE
202 ERROR #:WRONG ANSWER FROM VAC-SYSTEM
203 ERROR #:HEATING IS ON
400 ERROR #:NO CONNECTION TO GON-SYSTEM
401 ERROR #:TIMEOUT ON GON-INTERFACE
402 ERROR #:WRONG ANSWER FROM GON-SYSTEM
403 ERROR #:POSITION NOT REACHED
404 ERROR #:SCAN FINISHED
405 ERROR #:ADDITIONAL AXIS CHANGED
600 ERROR #:NO CONNECTION TO CAM-SYSTEM
601 ERROR #:TIMEOUT ON CAM-INTERFACE
602 ERROR #:WRONG ANSWER FROM CAM-SYSTEM
603 ERROR #:MULTI EXPOSURE OFF
604 ERROR #:CAM STATUS ERROR
605 ERROR #:NOT ENOUGH FILM SUPPLY
606 ERROR #:35MM TRANSPORT NOT ALLOWED
700 ERROR #:STEM ERROR TIMEOUT
701 ERROR #:IN SLOW SCAN MODE ONLY
800 ERROR #:NO CONNECTION TO GUN-SYSTEM
801 ERROR #:TIMEOUT ON GUN-INTERFACE
802 ERROR #:WRONG ANSWER FROM GUN-SYSTEM
803 ERROR #:TIMEOUT ON δ E-SCAN
804 ERROR #:RECEIVED DATA IS NO INTEGER
805 ERROR #:UNKNOWN HV-VOLTAGE SYSTEM
900 ERROR #:WRONG COMMAND OR PARAMETER
903 ERROR #:RECEIV. COMMAND NOT COMPLETE
904 ERROR #:RECEIV. CHAR. IS NO INTEGER
905 ERROR #:UNKNOWN COMMAND
906 ERROR #:VALUE OUT OF RANGE
907 ERROR #:VACUUM NOT CLEAR
908 ERROR #:MULTI EXPOSURE ON
909 ERROR #:FUNCTION ONLY IN MAG-MODE
910 ERROR #:ACTUAL MACRO NOT FINISHED
911 ERROR #:REMOTE IS OFF

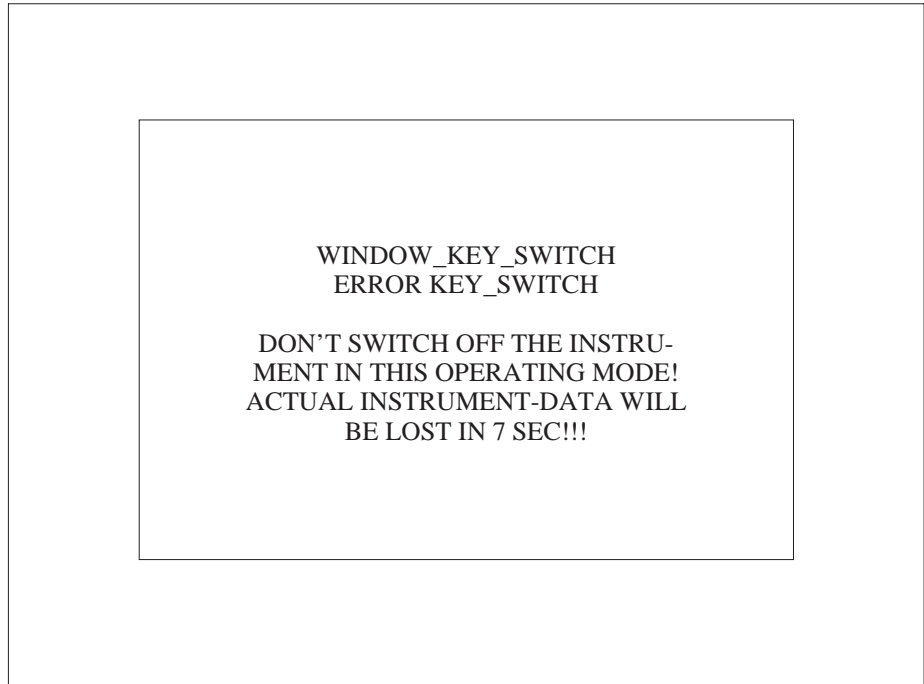
Critical error messages

Any critical error opens on the EL display a message window with the corresponding error message.

The following messages are possible:

Wrong key switch operation

If the key switch is operated and the instrument is not in the START menu, a warning is issued:



- Quit the actual menu and return to the START menu before you turn off the instrument with the key switch.

**CAUTION:**

Important instrument data are lost in 7 seconds if the key switch is not instantly reset.

Monitoring operating parameters

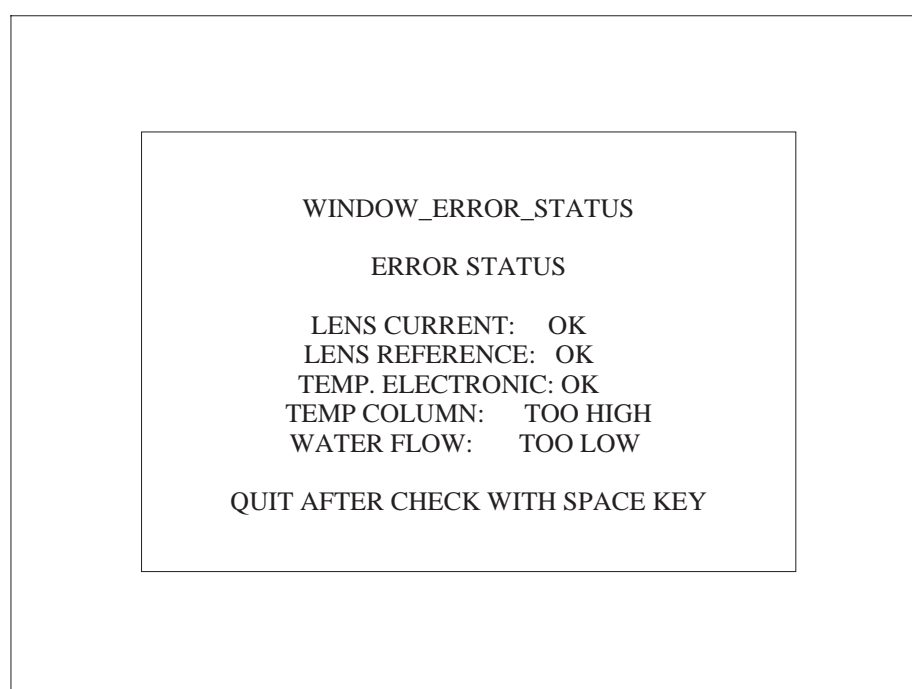
Five operating parameters are continuously monitored:

- Lens current Status: OK or TOO LOW
- Lens reference Status: OK or TOO LOW
- Temperature of
 lens current control Status: OK or TOO HIGH
- Column temperature Status: OK or TOO HIGH
- Water flow Status: OK or TOO LOW

If any of the limits is exceeded, the following message is issued:

Example:

If the water flow is too low the column will be overheated



If an error occurs, high voltage and lens current power supplies are turned off.

Procedure if an error occurs:

- Check cause of error (instrument installation conditions, water supply, ambient temperature, water temperature, etc.). In case of temperature problems allow the instrument to cool down.
- Confirm error with space key:
 - lens current power supplies are turned on when the error was eliminated. Continue working.
 - lens power supplies cannot be turned on if the error continues to exist. Please call the maintenance service.

5

Adjustment

Table of contents

5	Adjustment	5-1
5.1	AIS adjustment	5-3
5.1.1	Overview	5-3
5.1.2	Fine adjustment of entire system	5-6
5.1.2.1	Base setting for central AIS aperture	5-6
5.1.2.2	Adjustment	5-9
5.1.2.3	Adjustment of UPPER SYSTEM for AIS steps 1-4	5-11
5.1.2.4	Storage of AIS OFFSET	5-12
5.1.2.5	Adjustment of HR UPPER offset	5-12
5.1.3	Coarse adjustment of entire system	5-14
5.2	Alignment	5-20
5.2.1	Calibration to factory-set values	5-20
5.2.2	Alignment of TEM and SPOT illumination	5-21
5.2.3	Filament centration	5-23
5.2.4	Optimization of beam alignment (BEAM ALIGNMENT)	5-28
5.2.5	Adjustment of optimum imaging plane	5-30
5.2.6	Adjustment of beam incidence	5-31
5.2.7	Insertion and centration of objective lens aperture	5-32
5.2.8	Adjustment of imaging stigmator	5-33
5.2.8.1	IMAGE mode	5-33
5.2.8.2	DIFFRACTION mode	5-35
5.2.9	Adjustment of illumination stigmator	5-36
5.2.9.1	TEM mode	5-36
5.2.9.2	SPOT mode	5-37
5.2.10	Alignment in LM mode	5-39
5.2.10.1	Adjustment of illumination correction	5-39
5.2.10.2	Adjustment of stigmator values	5-41

5.1 AIS adjustment

5.1.1 Overview

Technical principle

A turret with five differently sized apertures is used for the magnification-controlled limitation of the luminous field in AIS mode. The turret is arranged in the principal plane of the 3rd condenser lens. The smallest aperture is concentric to the optical axis; the remaining four are arranged at a small distance around the central opening, each at an angular distance of 90°. The upper (condenser) deflecting system deflects the illuminating electron beam to the four off-axis apertures. The lower deflecting system (Scan System) operating synchronously with the condenser deflecting system, redeflects on the optical axis the beam limited by the aperture.

This allows multi-stage adaptation of the luminous surface to the magnification (see also section 1.2.2).

For AIS adjustment the following values must be set for each of the four *off-axis* apertures:

- Offset for deflection of the luminous field by the upper deflecting system
- Offset for redeflection of the aperture image to the optical axis by the lower deflecting system
- Stigmator value
- Correction of beam incidence

With increasing magnification the following assignment applies for change to the next aperture:

M = 3 150x to 37.5µm aperture (step 0) (aperture must be removed)

M = 4,000x to 600µm aperture (step 1)

M = 16,000x to 300µm aperture (step 2)

M = 31,500x to 150µm aperture (step 3)

M = 63,000x to 75µm aperture (step 4)

M = 125,000x to 37.5µm aperture (step 0)

At 125,000x magnification a change is made to the 37.5 µm aperture. This central aperture on the turret is concentric to the optical axis which deactivates the AIS deflection offset. The central aperture is also used for magnifications below 4,000x; the luminous field is then limited by 2-stage variation of the zoom image plane (ZIP 1 and 2).



SPECIAL NOTE:

At magnifications < 8,000x the large fluorescent screen is not fully illuminated in AIS mode. The photographic format may be cut off at 4,000x magnification.

The following adjustments are described in this chapter:

- Fine adjustment of entire system
- Coarse adjustment of entire system (necessary only after aperture exchange)

There is a calibration data set for each AIS step, which is activated by pushing the softkey CALIBR. AIS OFFS. A new calibration data set determined after aperture exchange can be stored on hard disk with the softkey STORE AIS OFFS. The most frequently used high-voltage step should be adjusted, because the AIS offset values are high-voltage-dependent. They are used as base values for fine adjustment at other HV steps and can be called with RECALL AIS OFFSET. There is a data set for each HV step storing the fine adjustment. The values are automatically copied in the data sets and stored.



SPECIAL NOTE:

Only *fine adjustment* is necessary in the LEO 912 OMEGA. It should be made every time the HV step is changed and before microscopy if the HV step is maintained.

CAUTION!

Base adjustment of the LEO 912 OMEGA must be made before AIS adjustment

(see section 4.8).

The C3 fine focus (encoder SPOT FOCUS) is automatically set to the left stop in AIS mode. It is invariable as long as AIS is activated.



Menu AIS ADJUST

Menu AIS ADJUST supports AIS adjustment and is called as follows:

- Activate AIS mode by pushing softkey AIS MODE in main menu: key field highlighted.
- Call menu PARAMETERS by pushing softkey PAR in main menu.
- Call menu AIS ADJUST by pushing softkey AIS ADJ. in menu PARAMETERS: menu AIS ADJUST displayed on monitor.

CAUTION!

If AIS mode was not activated in the main menu error message 13 *AIS ist nicht eingeschaltet (AIS not activated)* is issued.

	ADJUST HR MODE	H R MODE		FREEZE M A G	M I S MODE	M I S SELECT	NEW AIS OFFS.
<p>M A G : 4 0 0 0 x A I S A D J U S T</p> <p>A I S STEP : 1 M I S STEP : 0</p> <p>A I S UPPER X > 267 0 STIG COR. X > -62 A I S UPPER Y > 1209 0 STIG COR. Y > -109</p> <p>A I S LOWER X > 35 TILT COR. X > -88 A I S LOWER Y > -1056 TILT COR. Y > -47</p> <p>MODE: < M > < IMAGE > ILLUM. ANGLE : 0.10 mrad EMISSION CUR. : < 1 µA</p> <p style="text-align: center;"><< USE ILLUMINATION KNOBS >></p>							
RETURN<	CALIBR. AIS OFFS.	CONST. BRIGHTN.		ADJUST AIS UPPER	ADJUST AIS LOWER	ADJUST STIG COR.	ADJUST TILT COR.

Version 3.20

5.1.2

Fine adjustment of entire system

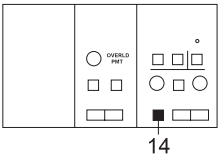
Preparations

- Calibrate image shift.
- Optimize base alignment
 - Filament alignment (FILAMENT ADJUST, FIL. PRECENT.)
 - Beam alignment (BEAM ALIGNMENT)
 - Alignment of eucentric axis to specimen (EUC. AXIS)
 - Beam incidence (BEAM TILT ADJUST)
 - Spectrometer adjustment
- Center object detail with trackball on small fluorescent screen.

5.1.2.1


Base setting for central AIS aperture

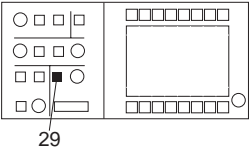
- Activate IMAGE mode (14).



14


IMAGE DIFF


- Activate TEM illumination mode (29).

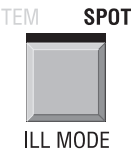


29


TEM SPOT



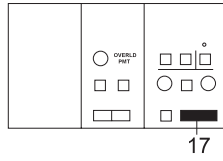
ILL MODE
- Set illuminating aperture to 1mrad.
- Center AIS aperture.
- Switch to SPOT illumination mode (29).



TEM SPOT



ILL MODE
- Adjust 100nm spot size.

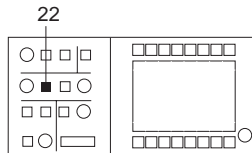


17



MAGNIFICATION

- Adjust for 125,000x magnification with keys MAGNIFICATION (17).

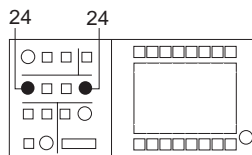


22

TILT SHIFT



- Activate illumination SHIFT mode (22).

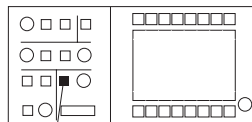


24

24

X Y

- Shift caustic to index point with encoders X and Y (24) in field ILLUMINATION.



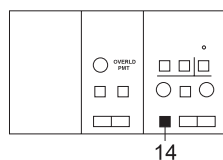
29

TEM SPOT



ILL MODE

- Activate TEM illumination mode (29).



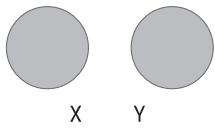
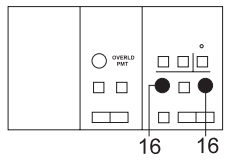
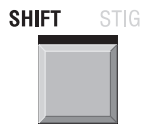
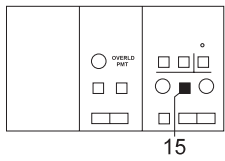
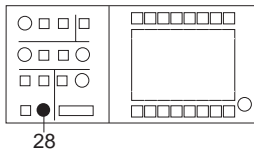
14

IMAGE DIFF



- Activate DIFF mode (14).

Version 3.20



- Adjust 580mm camera length.
- Center objective lens aperture.
- Focus aperture edge (diffraction point) with encoder OBJECTIVE (28) in field FOCUS.
- Activate IMAGE SHIFT mode (15).
- Shift diffraction point to index point with encoders X and Y (16) in field IMAGE.

5.1.2.2

Adjustment

Base adjustment for the central AIS aperture with deactivated AIS system is followed by AIS correction for the off-axis apertures.

Because the adjustments of the individual systems influence each other the following order is recommended for fine adjustment (steps 1 to 16).

- Activate AIS mode.

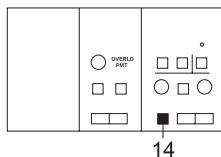
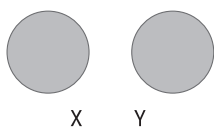
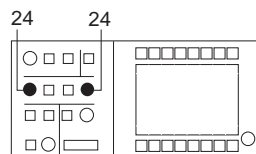
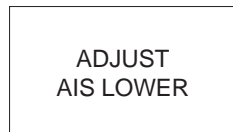
SPECIAL NOTE:

The 37µm AIS aperture used at magnifications above 125,000x produces on the specimen a luminous field with a diameter of approx. 1µm. Temperature changes of the aperture holder due to brightness changes cause minor drift, which shifts the luminous field. As this influences the alignment the illuminating aperture should be varied only slightly or not at all during fine adjustment.

Adjustment steps

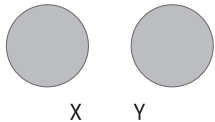
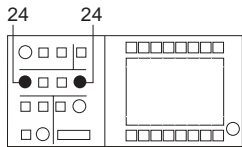
Steps 1 to 16 described below must be carried out separately for each of the four AIS steps.

1. Decrease magnification by 3 steps (= 63,000x).
2. Push softkey ADJUST AIS LOWER and center aperture image on large fluorescent screen with encoders X and Y (24) in field ILLUMINATION (correct luminous-field cut-off).
3. Activate DIFF mode (14).



Version 3.20

ADJUST STIG CORR.

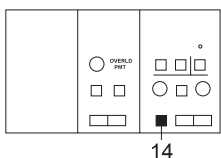
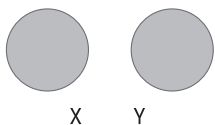


4. Through-focus diffraction image with objective lens focus.
5. In case of noticeable astigmatism of diffraction image zero beam:
Push softkey ADJUST STIG CORR. and compensate astigmatism (circular shape of luminous spot) with encoders X and Y (24) in field ILLUMINATION.

SPECIAL NOTE:

Strong astigmatism can make the zero beam to lie behind the aperture edge with STIGMATOR CORRECTION. The zero beam is then reset to the center of the aperture image with ADJUST TILT CORR.; continuation with ADJUST STIG CORR.

ADJUST TILT CORR.



6. Push softkey ADJUST TILT CORR. and center zero beam to objective lens aperture image with encoders X and Y (24) in field ILLUMINATION (shift luminous spot to center of small fluorescent screen).

7. Switch to IMAGE mode (14).

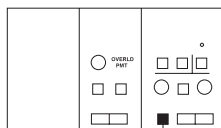
IMAGE DIFF



ADJUST AIS LOWER

8. If the condenser aperture cuts off the image correct with ADJUST AIS LOWER (repeat steps 2 to 7).

9. Switch to 31,500x magnification.
Carry out adjustment steps 2 to 8.
10. Switch to 16,000x magnification.
Carry out adjustment steps 2 to 8.



11. Switch to 8,000x magnification.
Carry out adjustment steps 2 to 8.
12. Switch to 125,000x magnification.
13. Check SPOT centration.
14. Check centration of condenser aperture.
15. Activate DIFF mode (14).
Check centration of objective lens aperture.

16. Quick check of AIS alignment:
Adjust successively 63,000x, 31,500x, 16,000x and 8,000x magnification and check centration in IMAGE and DIFFR. modes. Correct noticeable offsets.

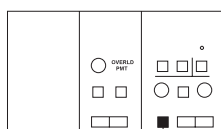
SPECIAL NOTE:

The modes CONSTANT BRIGHTNESS and AIS can be used to minimize any shift of the diffraction point with brightness variation. CONSTANT BRIGHTNESS mode requires fine correction of beam incidence (steps 3 to 6).

5.1.2.3

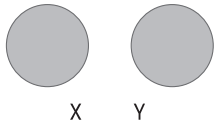
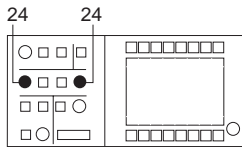
Adjustment of UPPER SYSTEM for AIS steps 1-4

The check is necessary only at greater intervals or if maximum image brightness is not obtained.



ADJUST
AIS UPPER

1. Activate IMAGE mode (14).
2. Adjust for 125,000x magnification.
3. Check beam alignment (BEAM ALIGNM.).
4. Adjust for 63,000x magnification.
5. Push softkey ADJUST AIS UPPER.
6. Increase the illumination angle to see any upper system misalignment.



7. Adjust maximum brightness of fluorescent screen center with encoders X and Y (24) in field ILLUMINATION.

8. Successively adjust for 31,500x, 16,000x and 8,000x magnification and repeat step 6 with every adjustment.

SPECIAL NOTE:

Should the brightness be too high at a magnification below 63,000x, reduce emission current!

9. Repeat fine adjustment according to step 16 after alignment of the UPPER SYSTEM.

5.1.2.4

Storage of AIS OFFSET

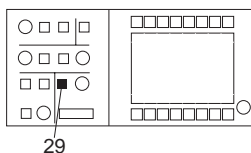
The calibration value for the softkey CALIBR. AIS OFFSET is overwritten with the softkey NEW AIS OFFS. Each aperture step must be separately stored. The AIS OFFSET calibration value is not high-voltage-specific, but is the initial value for AIS alignment at other high-voltage steps. AIS OFFSET should be executed and stored at the most frequently used high-voltage step. Fine adjustment at the individual HV steps is automatically stored on hard disk.

STORE
AIS OFFSET

- Push softkey NEW AIS OFFSET and quit with (Y).

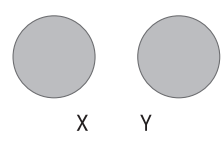
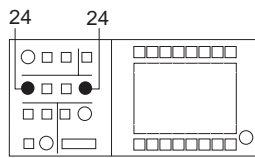
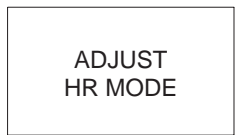
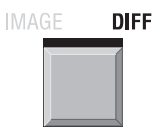
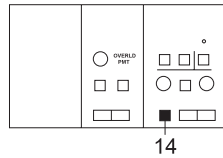
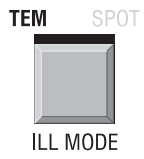
5.1.2.5

Adjustment of HR MODE



- Activate TEM mode (29).

- Center condenser aperture to $\leq 75\mu\text{m}$.



- Adjust for 125,000x magnification.
- Activate TEM mode (29).

- Select 1.6mrad illuminating aperture.
- Activate AIS mode.

- Call menu AIS ADJUST.

- Activate DIFF mode (14).

- Shift diffraction spot to index point with IMAGE SHIFT.
- Activate HR mode.

- Activate ADJUST HR MODE.

- Shift diffraction spot again to index point with encoders X and Y (24) in field ILLUMINATION.

Version 3.20

5.1.3

Coarse adjustment of entire system**CAUTION!**

Required only as initial adjustment or after aperture exchange!

Included in the step *preparations* is the exact centration of the beam and removal of the AIS multi-hole aperture from the beam path.

As next step (ADJUST AIS UPPER) the upper deflecting system deflects the beam for each of the four AIS steps so that it would roughly hit the aperture for the corresponding step if the multi-hole aperture were in the beam path. The offset of the lower deflecting system for beam redeflection is set to zero. The luminous field (defined by the fixed C2 aperture) is displayed on the fluorescent screen in the clock hand position which corresponds to the position of the aperture in the turret. The deflection offset is stored.

The following assignment applies for $M = 3,150\times$:

AIS step	Magnification	Luminous-field position
1	4,000	7 o'clock
2	16,000	1 o'clock
3	31,500	10 o'clock
4	63,000	4 o'clock

To maintain the same imaged area for all AIS steps push the softkey FREEZE MAG before beam deflection. This "freezes" the magnification: it is maintained at the value adjusted with call of the function FREEZE MAG, even if new values are adjusted with the double key MAGNIFICATION and displayed on the monitor. All parameters linked with the magnification (focus step size, selection of AIS steps) are executed automatically.

In a last step (ADJUST AIS LOWER) the luminous field is redeflected by the lower deflecting system to the center of the fluorescent screen from the clock hand position of the AIS step. The redeflection offset is also stored.

Preparations

- Deactivate AIS mode in main menu.
- Activate TEM mode (29).

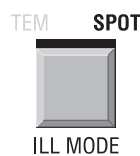
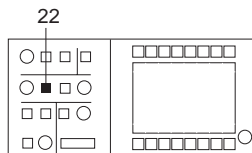
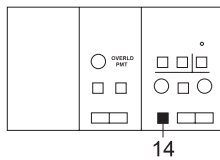
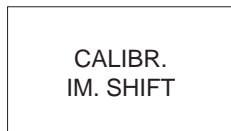
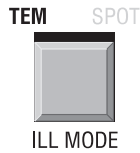
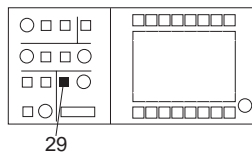
- Push key CALIBR. IM. SHIFT in menu CALIBRATION (see section 3.4.1).

- Activate IMAGE mode (14).

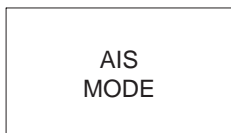
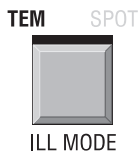
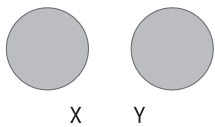
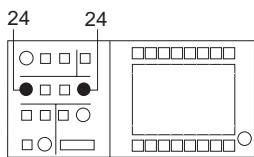
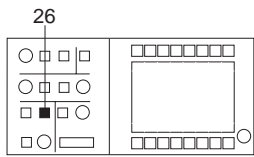
- Insert central 37.5 μm item of 5-hole aperture and center shadow image with adjusting knobs on aperture drive.

- Select SHIFT mode (22).

- Change to SPOT mode (29).



Version 3.20



- Calibrate objective lens to eucentric axis with key CALIBRATE (26) in field FOCUS.

- Adjust for 125,000x magnification.

- Shift luminous spot to center of fluorescent screen with encoders X and Y (24) in field ILLUMINATION.

- Switch to TEM mode (29), adjust for 3,150x magnification.

- Remove 5-hole aperture from beam path.

- Activate AIS mode with softkey AIS MODE in main menu, call menu AIS ADJ.

- Push softkey FREEZE MAG.
 - Key field highlighted.
 - All AIS functions operate normally, but the magnification is frozen at 3,150x.

Adjustment steps

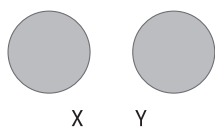
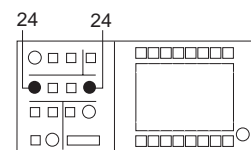
The following adjustment steps must be made separately for each of the four AIS steps.

- Adjust magnification:

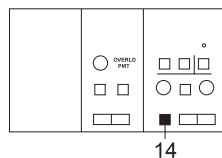
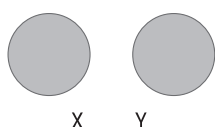
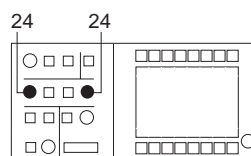
- Step 1: 4,000x
- Step 2: 16,000x
- Step 3: 31,500x
- Step 4: 63,000x

- Overwrite the previous value by pushing the softkey NEW AIS OFFS. Quit with (Y).

ADJUST
AIS UPPER

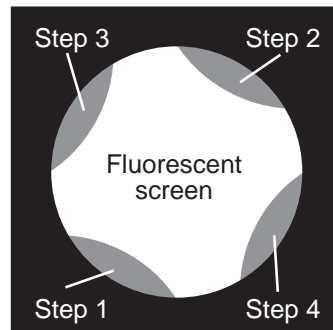


ADJUST
AIS LOWER



CALIBR.
IM. SHIFT

- Push softkey ADJUST AIS UPPER.
- With encoders X and Y (24) in field ILLUMINATION shift center of luminous field over edge of fluorescent screen to the clock hand position corresponding to the AIS step. The distance between edge of luminous field and edge of fluorescent screen should be approx. 2cm (see right Fig.):
Step 1: 7 o'clock
Step 2: 1 o'clock
Step 3: 10 o'clock
Step 4: 4 o'clock



- Push softkey ADJUST AIS LOWER.
- Shift luminous field center back to center of fluorescent screen using encoders X and Y (24) in field ILLUMINATION.

- Make AIS fine adjustment (see section 5.1.2).

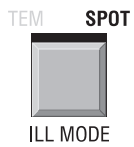
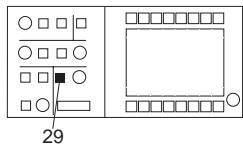
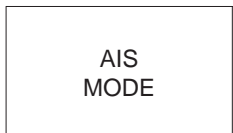
Adjustment of UPPER system for AIS step 0

The condenser deflection system must be corrected only after mechanical shift of the condenser system.

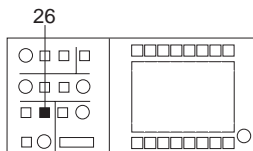
The value is used to correct the spot position at d@ 4nm. This adjustment influences the illumination adjustment in general.

- Activate IMAGE mode (14).
- Push softkey CALIBR. IM. SHIFT of menu CALIBRATION (see section 3.4.1).

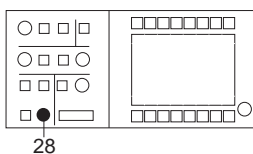
Version 3.20



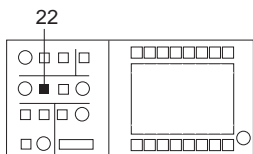
- Activate AIS mode.
- Activate SPOT mode (29).



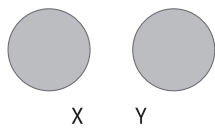
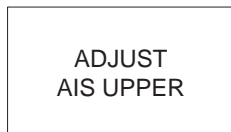
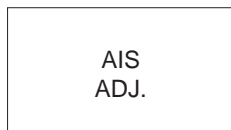
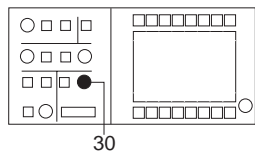
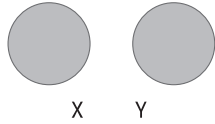
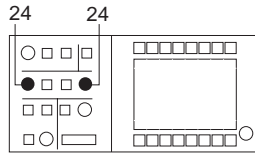
- Adjust 4nm spot size.
- Adjust illuminating aperture to 0.1mrad.
- Adjust for 20,000x magnification.
- Calibrate objective lens to eucentric axis with key CALIBRATE (26) in field FOCUS.



- Adjust caustic with encoder OBJECTIVE (28) in field FOCUS.



- Select SHIFT mode with key TILT/SHIFT (22) in field ILLUMINATION.



- Shift caustic to index point with encoders X and Y (24) in field ILLUMINATION.

- Adjust 1.6nm spot size.
- Adjust caustic with encoder SPOT FOCUS (30), if necessary.

- Call menu AIS ADJUST.

- Push softkey ADJUST AIS UPPER and shift caustic to index point with encoders X and Y (24).

- If necessary, overwrite actual AIS value with softkey NEW AIS OFFS. and quit with (Y).

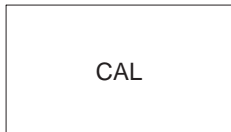
- Repeat the above steps, if necessary.

Version 3.20

5.2 Alignment

5.2.1 Calibration to factory-set values

The state of the instrument upon leaving the factory can be reestablished. The menu CALIBRATE is used to reset all instrument parameters and settings to the factory settings.



- Call menu PARAMETERS with softkey PAR in main menu. PARAMETER menu is displayed on the monitor.
- Call menu CALIBRATE with softkey CAL. Menu CALIBRATE is displayed on the monitor.



For a detailed description of the menu CALIBRATE see section 3.4.1.

Call of calibration values

Calibration values are base settings for alignment of the illumination and imaging systems. Execution of the function sets the selected setting to the calibration value. These are factory settings which may be changed only by a qualified service engineer.

The calibration function is executed only for the actually selected imaging and illumination mode, e.g. for ILL. SHIFT if adjusted. ILL. TILT and ILL. SHIFT are reset for calibration of the value ILL. DEFLECT.

The following calibration functions must be executed:

- | | |
|-------------------|--|
| CALIBR. IM. SHIFT | before each instrument alignment, because the image shift system will shift the magnification center. |
| CALIBR. ILL. DEFL | if the spot is invisible. |
| CALIBR. FOCUS | for adjustment of the objective lens to the eucentric axis. The function corresponds to the key CALIBRATE in the field FOCUS on the right control panel. |
| CALIBR. MAG. | to increase the reproducibility of magnification. Drives all projector lenses starting from highest current value. Elimination of lens hysteresis. |
| CALIBR. IM. STIG. | for base adjustment of imaging stigmator. |
| CALIBR. ILL. STIG | for base adjustment of illumination stigmator. |
| CALIBR. ALL | for calibration of all above parameters. |



SPECIAL NOTE:

A specific instrument setting previously stored in the menu USER may be recalled and reset from the menu USER.

5.2.2

Alignment of TEM and SPOT illumination

There are two ways to center the luminous field in TEM illumination:

- Mechanically by shifting the condenser aperture
- Electrically using encoders ILLUMINATION X and Y with activated SHIFT.

Exact precentering is possible only in SPOT mode. The electrical centration should be made before the mechanical.

Electrical centration

- Select illumination shift with SHIFT (22).

- Adjust for $\geq 8,000\times$ magnification.

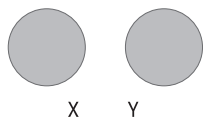
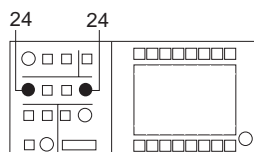
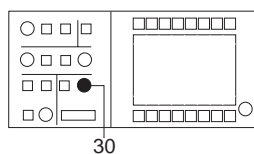
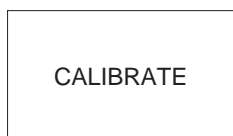
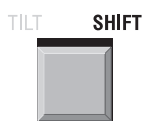
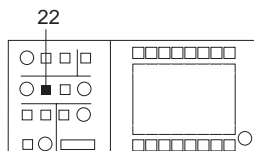
- Activate SPOT mode (29).

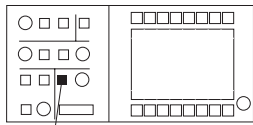
- Adjust 10nm spot size.

- Push key CALIBRATE.

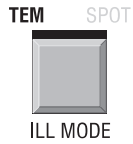
- Adjust spot with encoder SPOT FOCUS (30) in field BRIGHTNESS.

- Shift caustic to index point with encoders X and Y (24) in field ILLUMINATION.





29



Mechanical condenser aperture centration

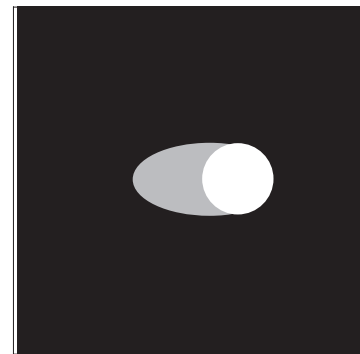
- Select TEM mode (29).

- Set illuminating aperture to 0.1mrad.
- Center condenser aperture symmetrically to index point (caustic center) with adjustment knobs on aperture drive.



SPECIAL NOTES:

1. If the luminous field shifts considerably during magnification change, check IMAGE SHIFT adjustment or AIS alignment. Minor deviations can be corrected with ILLUMINATION SHIFT.
2. If the spot has a halo (see right Fig.) with centered condenser aperture, check the beam incidence.
3. Minor shift of the spot on the fluorescent screen during magnification change (analogous to the image of the object detail in TEM illumination mode).
4. Major changes in condenser zoom step require correction of mechanical drift by mechanical realignment of the condenser aperture to maintain the general alignment state.



Spot if incidence direction is wrong

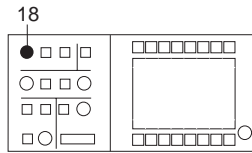
5.2.3

Filament centration

The filament is centered using the underheated filament image. Filament alignment is possible either in IMAGE and SPOT modes or in DIFF and TEM modes.

Presettings

- Adjust emission current to 10 - 20 μ A with encoder CURRENT (18).



CURRENT

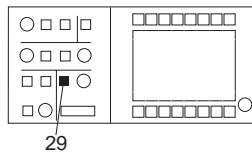


- In main menu call menu GUN with softkey GUN.

- Push softkey FIL. CURRENT.

Filament centration in IMAGE mode

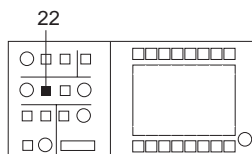
- Select TEM mode (29).



TEM SPOT



ILL MODE

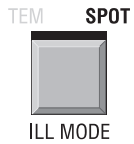
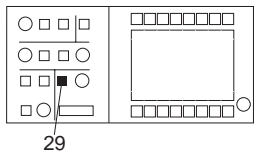


TILT SHIFT

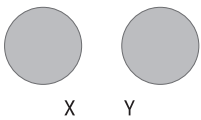
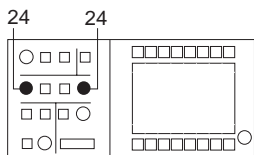


- Select SHIFT mode (22).

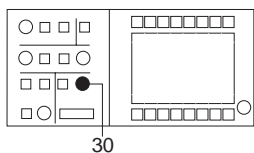
- Center condenser aperture[®] 75 μ m (step 4).



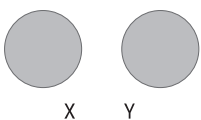
- Activate SPOT mode (29).



- Adjust for approx. 100,000x magnification.
- Center spot with encoders X and Y (24) in field ILLUMINATION.

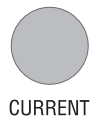
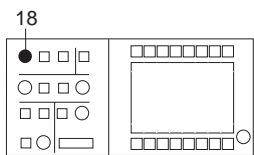


- Focus spot with encoder SPOT FOCUS (30) in field BRIGHTNESS.

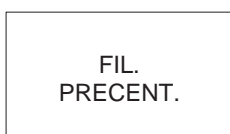


- In case of spot astigmatism spot, adjust circular spot with encoders X and Y (24) in field ILLUMINATION.

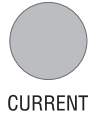
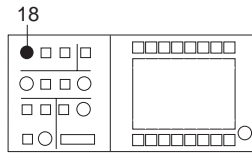
- Adjust approx. 80nm spot size.



- Adjust underheated filament image with encoder CURRENT (18) (refocus, if necessary).



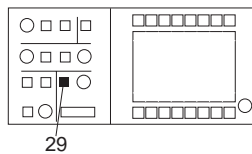
- Push softkey FIL. PRECENT.
- Symmetrize filament image with encoders X and Y (24) in field ILLUMINATION.
- Optimize illumination astigmatism, if necessary (encoders X and Y (24) in field ILLUMINATION).



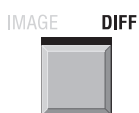
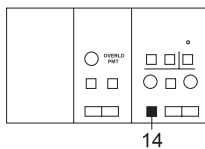
- Increase filament current with encoder CURRENT (18) until no filament structure is visible (filament saturation).

- Store filament alignment on hard disk with softkey STORE GUN ALIGN.

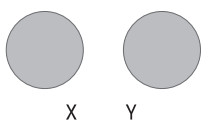
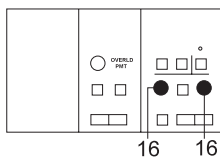
Filament centration in DIFF mode (alternative method)



- Select TEM mode (29).

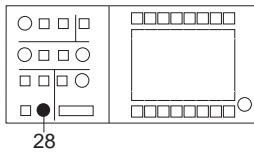


- Center condenser aperture $\leq 400 \mu\text{m}$ in IMAGE mode.
- Select DIFF mode (14) in field IMAGE.

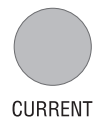
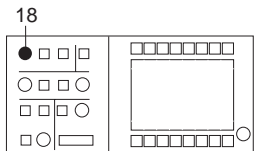


- Set camera length (CL) to approx. 2900mm.
- Center diffraction point with encoders X and Y (16) in field IMAGE.

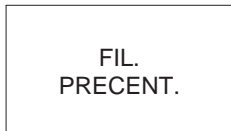
Version 3.20



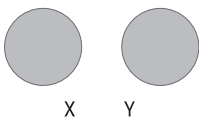
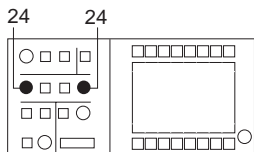
- Focus diffraction point with encoder OBJECTIVE (28) in field FOCUS.



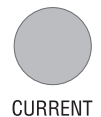
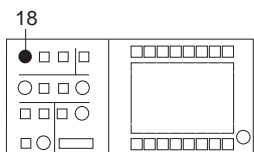
- Adjust underheated filament image with encoder CURRENT (18) (refocus, if necessary).



- Push softkey FIL. PRECENT.



- Symmetrize filament image with encoders X and Y (24) in field ILLUMINATION.



- Increase filament current with encoder CURRENT (18) until no filament structure is visible (filament saturation).



- Store filament alignment on hard disk with softkey STORE GUN ALIGN.

**SPECIAL NOTES:**

1. The filament heating current depends on the high voltage and the emission current.
2. Beam alignment is necessary every time the filament is aligned (see section 5.2.4).

5.2.4

Optimization of beam alignment (BEAM ALIGNMENT)

BEAM ALIGNMENT can be used to minimize changes in beam incidence (Spot Position) with variation of the illuminating aperture (Spot Size).

Beam alignment considerably influences base alignment and AIS alignment. The beam alignment should be checked before correcting the AIS alignment.

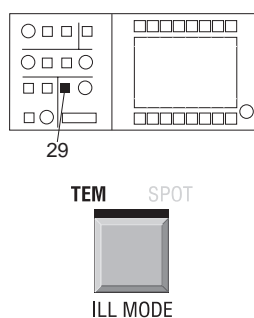
Realignment is necessary if the position of the zero beam in the diffraction image is shifted (relative to the image of the objective lens aperture) with brightness changes.

Requirement

- Filament centered (see section 5.2.3)

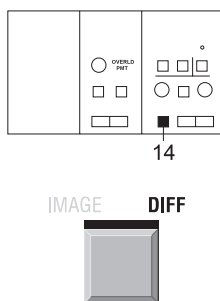
Presettings

- Select TEM mode (29).



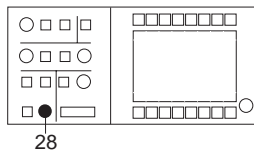
- Adjust for 50,000x magnification.
- Center condenser aperture $\leq 400 \mu\text{m}$.

- Select DIFF mode (14).

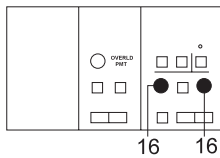


- Adjust 580mm camera length (CL).
- In the main menu call menu GUN with softkey GUN.

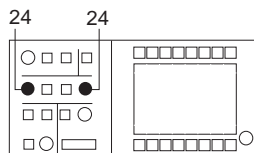
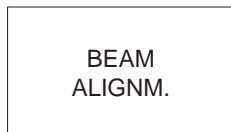




OBJECTIVE



X Y



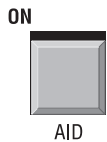
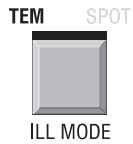
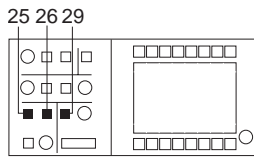
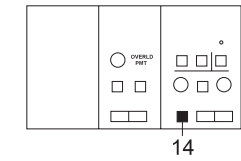
X Y



Procedure

- Adjust 0.06mrad illuminating aperture.
- Focus diffraction point with encoder OBJECTIVE (28) in field FOCUS.
- Shift diffraction point to index point in center of fluorescent screen with encoders X and Y (16) in field IMAGE.
- Push softkey BEAM ALIGNM.
- Increase illuminating aperture to 1.6mrad.
- Correct shift of diffraction point with encoders X and Y (24) in field ILLUMINATION
- Repeat the above steps to increase the precision.
- Store beam alignment with softkey STORE GUN ALIGN.

5.2.5

Adjustment of optimum imaging plane
(eucentric axis)

- Activate IMAGE mode with key IMAGE / DIFF (14) in field IMAGE.

- Activate TEM mode with softkey ILL. MODE (29) in field BRIGHTNESS.

- Calibrate objective lens to eucentric axis by pushing key CALIBRATE (26) in field FOCUS.

- Insert specimen. Observe object detail in center of small fluorescent screen.

- Activate focusing aid with key AID (25) in field FOCUS.

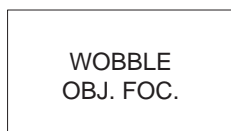
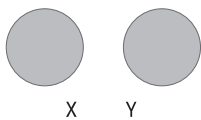
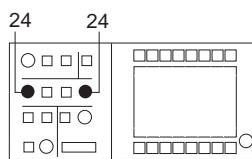
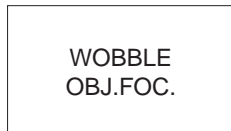
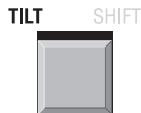
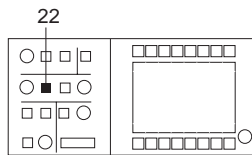
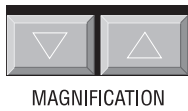
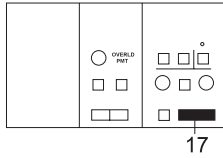
- Shift goniometer Z axis with keys Z-CONTROL + and – until the observed object detail stands still.

- Deactivate focusing aid with key AID (25).

Fine adjustment (required only when using goniometer tilt)

- If the object detail shifts when tilting (key TILT + and –) make vertical adjustment with keys Z-CONTROL + and –.

5.2.6



Adjustment of beam incidence

- Adjust for 31,500x magnification with double key MAGNIFICATION (17).
- Adjust illumination tilt with key TILT/SHIFT (22) in field ILLUMINATION.
- Call menu PARAMETERS with softkey PAR in main menu.
- Push softkey FOCUS PAR.
- To wobble the objective lens focus: push softkey WOBBLE OBJ. FOC.. The key is highlighted.
- Shift encoders X and Y (24) in field ILLUMINATION until the observed object feature stands still.
- Deactivate wobbling with softkey WOBBLE OBJ. FOC..

5.2.7

Insertion and centration of objective lens aperture

Insertion and centration of the objective lens aperture are described in chapter 4, section 4.8.6, the adjustment is described in this section.



SPECIAL NOTE:

A help program is available for adjustment of the objective lens aperture (see section 5.3).

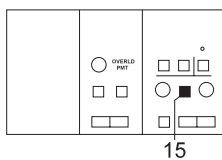
5.2.8

Adjustment of imaging stigmator

The required objective lens aperture must be centered.

For all settings described below the encoders X and Y in field IMAGE must be switched to the function *imaging stigmator*.

- Adjust function STIG with key SHIFT / STIG (15) in field IMAGE.



5.2.8.1

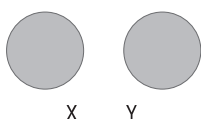
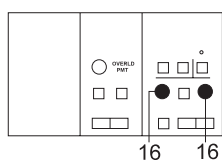
IMAGE mode

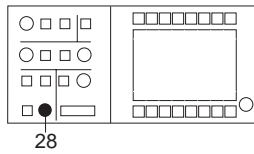
Presettings:

- IMAGE mode, magnification at least 100,000x
- TEM mode, aperture $\leq 1.6\text{mrad}$
- Condenser aperture with max. $75\mu\text{m}$ hole diameter inserted.

Compensation of astigmatism using the grain

- Insert strongly dispersive specimen.
- Adjust imaging stigmator with encoders X and Y (16) in field IMAGE so that the specimen grain does not display a privileged direction when through-focusing with encoder OBJECTIVE (28) in field FOCUS.



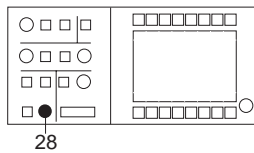
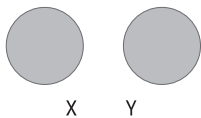
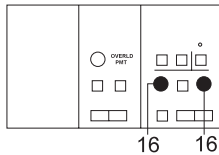


SPECIAL NOTE:

See the special notes in chapter 4, section 4.3.9. (**überprüfen**)

Compensation of astigmatism using the Fresnel fringe

- Insert perforated foil (Holy grid).
- Adjust imaging stigmator with encoders X and Y (16) in field IMAGE so that the Fresnel fringe is symmetrical to the hole edge when slightly overfocusing with encoder OBJECTIVE (28) in field FOCUS.

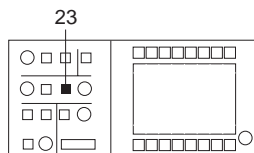


5.2.9

Adjustment of illumination stigmator

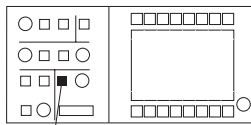
The encoders X and Y in field ILLUMINATION must be switched to the function *illumination stigmator* for all settings described below.

- Select function STIG with key DEFL / STIG (23) in field ILLUMINATION.

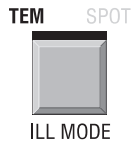


Version 3.20

5.2.9.1



29



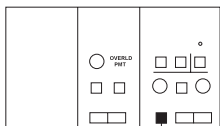
TEM mode

- Activate TEM mode (29).

Compensation of astigmatism using the diffraction point

Requirement:

- Imaging astigmatism compensated in DIFF mode.



14

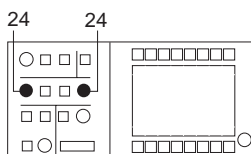


- Activate IMAGE mode (14).

- Adjust for 12,500x magnification.

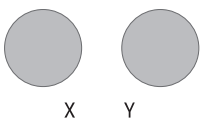
- Center condenser aperture.

- Switch to DIFF mode (14).



24

24



X

Y

- Adjust illumination stigmator with encoders X and Y (24) in field ILLUMINATION until the diffraction point is of circular shape.

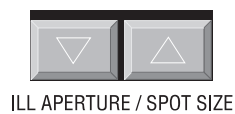
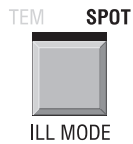
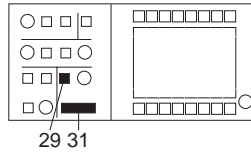
5.2.9.2

SPOT mode

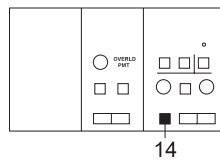
Requirement:

- Imaging astigmatism compensated in IMAGE mode.
- Remove objective lens aperture.

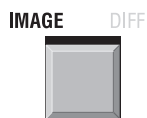
- Activate SPOT mode (29).



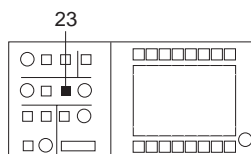
- Select spot size $\leq 10\text{nm}$ with key SPOT SIZE (31) in field BRIGHTNESS.



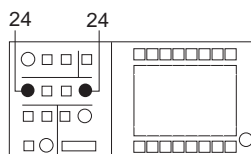
- Activate IMAGE mode (14).



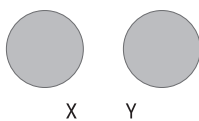
- Adjust $\geq 10,000\times$ magnification.



- Select function STIG with key DEFL / STIG (32) in field ILLUMINATION.



- Adjust illumination stigmator with encoders X and Y (24) in field ILLUMINATION until the spot is of circular shape.



5.2.10

Alignment in LM mode

5.2.10.1

Adjustment of illumination correction

Beam shift

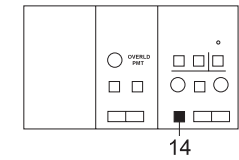
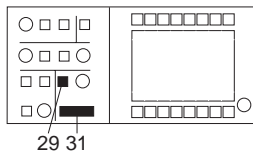


IMAGE DIFF



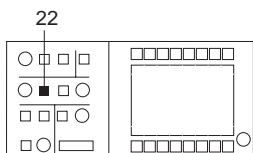
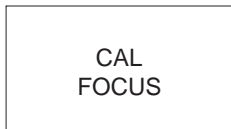
TEM SPOT



ILL MODE



ILL APERTURE / SPOT SIZE



TILT SHIFT



- Activate IMAGE mode (14).

- Activate SPOT mode (29).

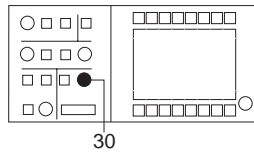
- Select spot size 2µm with key SPOT SIZE (31).

- Push softkey CAL FOCUS.

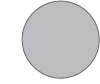
SPECIAL NOTE: For specimen protection the Beam Blanker is activated during calibration.

- Activate beam shift with key SHIFT / TILT (22) in field ILLUMINATION.

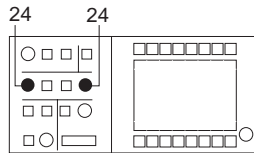
- Adjust for 2,000x magnification.



30



SPOT FOCUS



24

24



X



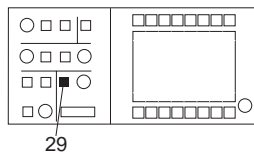
Y

- Adjust caustic with encoder SPOT FOCUS (30).

- Shift caustic to index point in center of fluorescent screen with encoders X and Y (24) in field ILLUMINATION.

Beam tilt

- Adjust TEM mode (29).

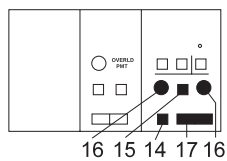


29

TEM SPOT



ILL MODE



16 15 14 17 16

IMAGE DIFF

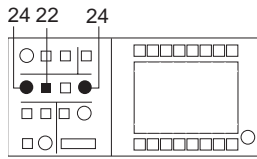


MAGNIFICATION

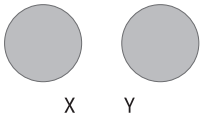
- Activate DIFFRACTION mode with key IMAGE / DIFF (14) in field IMAGE.

- Adjust diffraction length CL = 580mm with double key MAGNIFICATION (17).

Version 3.20



TILT SHIFT



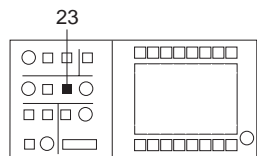
- Activate beam tilt with key SHIFT / TILT (22).

- Shift diffraction point to index point in center of fluorescent screen with encoders X and Y (24) in field ILLUMINATION.

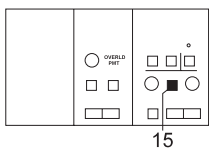
5.2.10.2

Adjustment of stigmator values

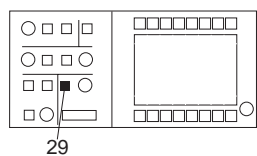
In IMAGE mode



DEFL STIG



SHIFT STIG



TEM SPOT



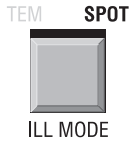
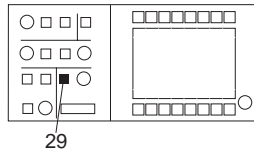
ILL MODE

- Select function STIG with key DEFL / STIG (23) in field ILLUMINATION.

- Activate function STIG with key SHIFT / STIG (15) in field IMAGE.

- Activate TEM mode (29).

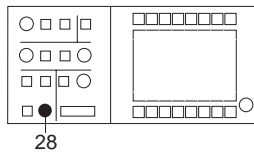
- Center 37.5µm condenser aperture.
- Insert dispersive specimen.



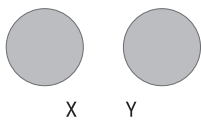
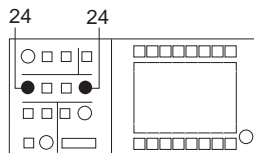
- Select SPOT mode (29).

- Push softkey CAL FOCUS.

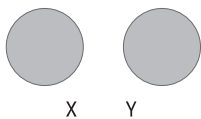
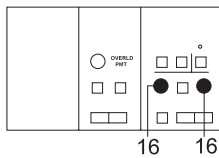
SPECIAL NOTE: For specimen protection the Beam Blanker is activated during calibration.



- Adjust halo with encoder OBJECTIVE (28) in field FOCUS (focus luminous spot with encoder SPOT FOCUS, if necessary).

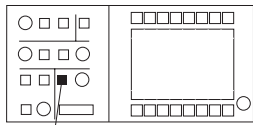


- Adjust circular halo with encoders X and Y (24) in field ILLUMINATION.

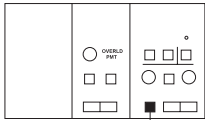
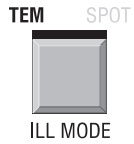


- Adjust circular spot with encoders X and Y (16) in field IMAGE.

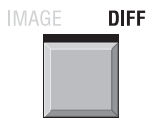
Version 3.20



29



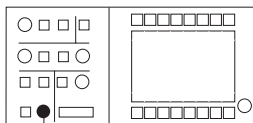
14



MAGNIFICATION



ILL MODE



28



OBJECTIVE

In DIFF mode

- Select TEM mode (29).

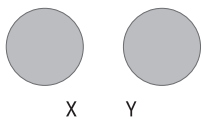
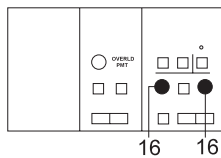
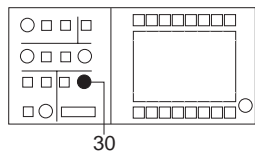
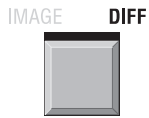
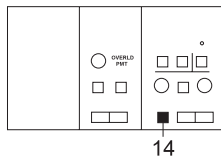
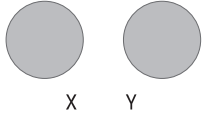
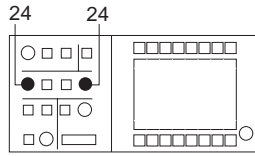
- Select DIFF mode (14).

- Adjust camera length CL = 10m with double key MAGNIFICATION (17).

- Center selector aperture 50μm.
- Adjust TEM mode (29).

- Remove condenser aperture.
- Adjust for 80x magnification.

- Adjust shadow ring with encoder OBJECTIVE (28) in field FOCUS (recenter selector aperture, if necessary).



- Adjust three-fold symmetry of shadow ring with encoders X and Y (24) in field ILLUMINATION.

- Remove selector aperture.

- Center condenser aperture 37.5µm.

- Select DIFF mode (14).

- Focus diffraction point with encoder SPOT FOCUS (30).

- Adjust circular diffraction point with encoders X and Y (16) in field IMAGE.

Version 3.20

5.3 Different settings and calibration

5.3.1 MDF setting

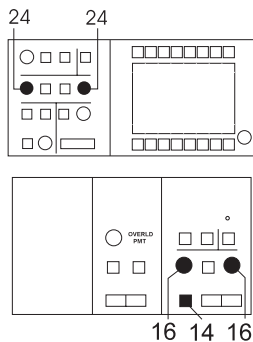
PARALLEL/ FREE	CHECK M D F	M I S MODE	M I S SELECT		RESET MDF OFFS.		
<p>M A G : 5 0 0 0 x MICRO DOSE FOCUSING</p> <p>M D F ADJUST MODE: FREE DOSE-RATE: -NOT-CAL e1/nm²s</p> <p>ILLUMIN.X OFFSET > 0 TILT COR. X > 0</p> <p>ILLUMIN.Y OFFSET > 0 TILT COR. Y > 0</p> <p>IMAGE X OFFSET > 0</p> <p>IMAGE Y OFFSET > 0</p> <p>MODE: < M > < IMAGE > EXP. TIME: sec</p> <p>ILLUM. ANGLE : 0.10 mrad FIX TIME: 2.4 sec</p> <p>EMISSION CUR.: < 1 µA FILM SUPPLY: 02</p> <p style="text-align: center;"><< USE ILLUMINATION/IMAGE KNOBS >></p> <p style="text-align: center;">MDF POS: 1 --> MAG: 5000 x</p>							
RETURN<	CALIBRATE DOSE-RATE	BEAM BLANKER	TOGGLE MDF POS	M D F REV. DIR.	M D F MODE	ADJUST MDF OFFS.	ADJUST TILT COR.

The MICRO DOSE FOCUSING menu allows the preset of different data sets for the 3 most used magnifications. The different presets can be selected by pushing the softkey TOGGLE MDF POS.

It is provided that the EM is ready for the preset. The desired magnification is selected and the brightness is reasonable. The objective lens aperture is introduced and centered.

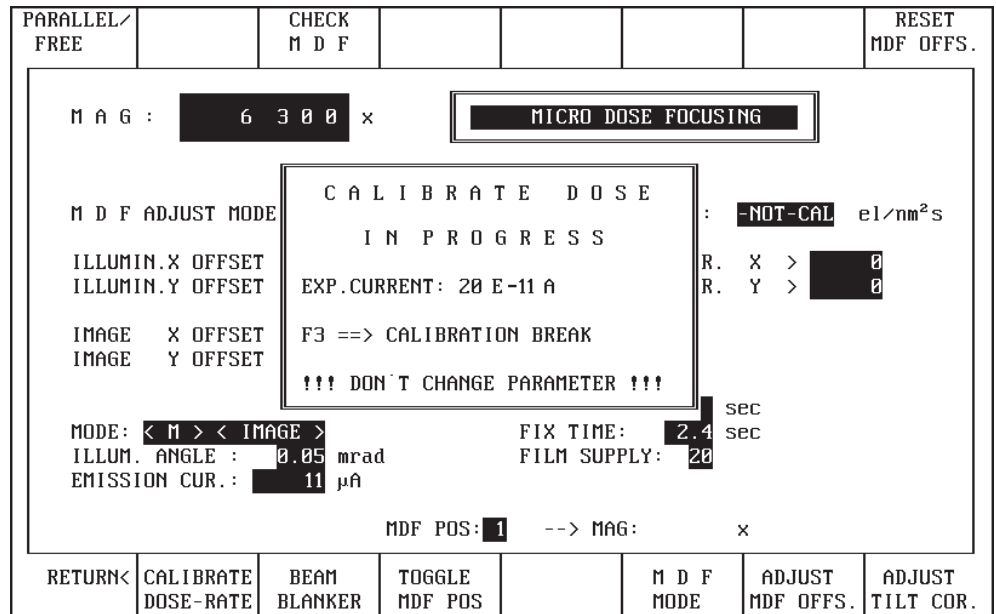
- Activate the menu MDF in the menu PARAMETER.
- Push the softkey MDF MODE, ADJUST MDF OFFS., and then RESET MDF OFFS. All offset values are set to zero.
- Deflect the illuminated field with encoders X and Y (24) in the field ILLUMINATION that the detection area (negative format or SSCCD area) is not illuminated anymore.
- Deflect the illuminated field back to the center of the large screen with encoders X and Y (16) in the field IMAGE.
- Switch to DIFF mode (14) and activate ADJUST TILT COR. in the MDF menu.
- Center the diffraction spot to the objective lens aperture with encoders (16).
- Deactivate ADJUST TILT COR.

The MDF setting is stored under the selected MDF POS. (1, 2 or 3). The magnification and even a MIS selection would be stored.



5.3.2 Dose rate calibration

For LOW DOSE work and for many other applications the electron dose plays an important role. The dose rate can be calibrated for each illumination angle and displayed all the time. The user is always aware of the dose for the next application.



For the dose rate calibration the specimen holder and all apertures below the specimen have been retracted. The illumination system has been aligned. The magnification is in medium range (approx. 20.000x). The large screen has been lifted.

- Push the button CALIBRATE DOSE-RATE.

An additional window is opened in the MICRO DOSE FOCUSING menu showing the progress of the dose rate calibration.

All illumination angles are selected automatically and the corresponding current is measured. Finally the dose rate is displayed in electrons/nm²s according to the selected illumination angle.

- Lower the large screen.

As long as the emission current or the high voltage is not changed the dose rate display is valid. For a new setting of the emission current or high voltage the calibration has to be repeated.

For the dose calculation the dose rate value has to be multiplied by the exposure time. The dimension for the dose is electrons/nm².



Care and Maintenance

Table of contents

6	Care and Maintenance	
6.1	General	6-3
6.2	Filament exchange	6-3
6.3	Anode exchange	6-6
6.4	Electrode cleaning	6-7
6.5	Assembly of filament holder	6-10
6.6	Mechanical adjustment of filament	6-11
6.7	Components of the tool kit	6-12
6.8	Reactivation after electrode exchange	6-13
6.9	Care of specimen holders	6-15
6.10	Aperture exchange	6-17
6.10.1	Aperture removal	6-17
6.10.2	Exchange of objective lens apertures and selector apertures	6-18
6.10.3	Condenser aperture exchange	6-19
6.11	Care of vacuum pump (rotary pump)	6-20
6.12	Cleaning the filter mats in the power supply cabinet	6-21
6.13	Preparation of backup floppies	6-22

6.1 General

For troublefree continuous operation of the instrument parts like filaments and apertures should be regularly exchanged, parts cleaned and conditions controlled.

Everything the user himself can do is described in this chapter. Any other manipulations on the instrument must be made by experienced and specifically trained service engineers, and should be covered by a service agreement.

6.2 Filament exchange

Requirement

- Key switch in position ON, i.e. vacuum system and host computer activated.
- “VAC READY” in the vacuum menu displays “YES”.

Important notes

If a filament is burnt out (displayed in menu GUN), or the illumination shows instabilities like spot flickering or strong arcs, exchange of the filament is necessary.

The anode should always be exchanged together with the filament. Filament and anode are referred to as electrodes.

- Alignment and mounting of the electrodes require utmost care and cleanliness. This applies in particular to the highly sensitive LaB6 filament.
- Always wear clean, lint-free cotton gloves for cleaning anode and filament parts.
- Always keep cleaned spare electrodes in store for quick exchange, which prevents humidity on the surfaces of the vacuum chamber. Long opening of the vacuum system means long pumpdown and waiting times after turn-ON until the final vacuum is restored, because all surfaces must be degassed.



Cleaning of filament and anode see section 6.4.

Ventilation and opening of specimen and filament chambers

- Push key VENT / EVAC COL in the VACUUM menu. If there is an additional Ion getter pump for the gun push key VENT / EVAC GUN.
 - Ion getter pump deactivated.
 - Filament chamber ventilated with dried nitrogen (max. pressure 0.3bar).
- After ventilation (approx. 60s) lift gun by pushing the key on gun lifter (Fig. 6-1) and swing gun away (Fig. 6-2).



SPECIAL NOTE:

Do not squeeze the O-ring seal when swinging the gun away!

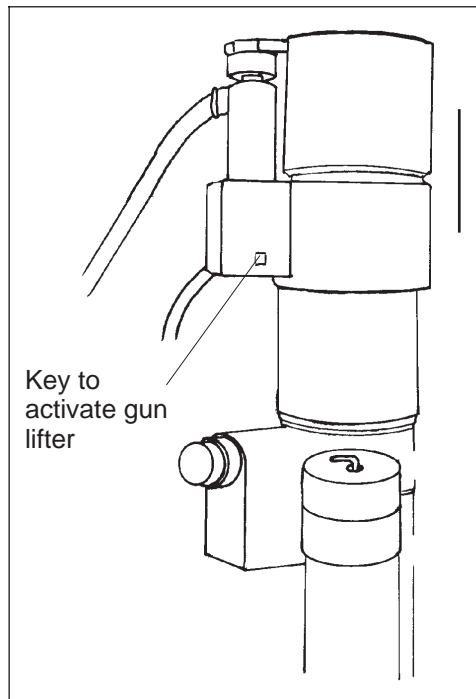


Fig. 6-1: Lifting gun

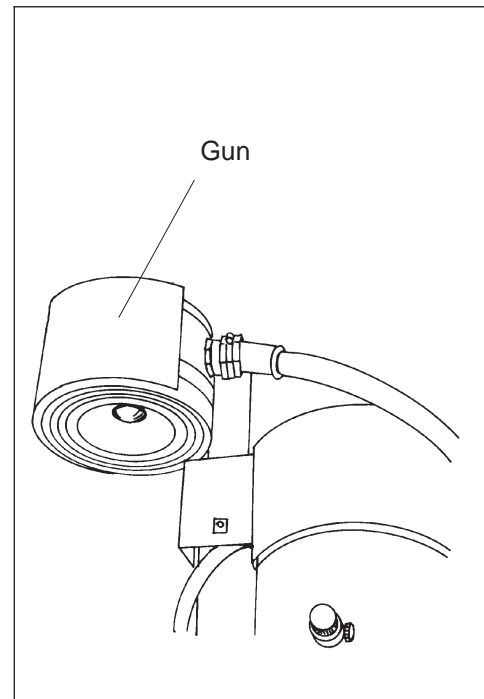


Fig. 6-2: Swinging away gun

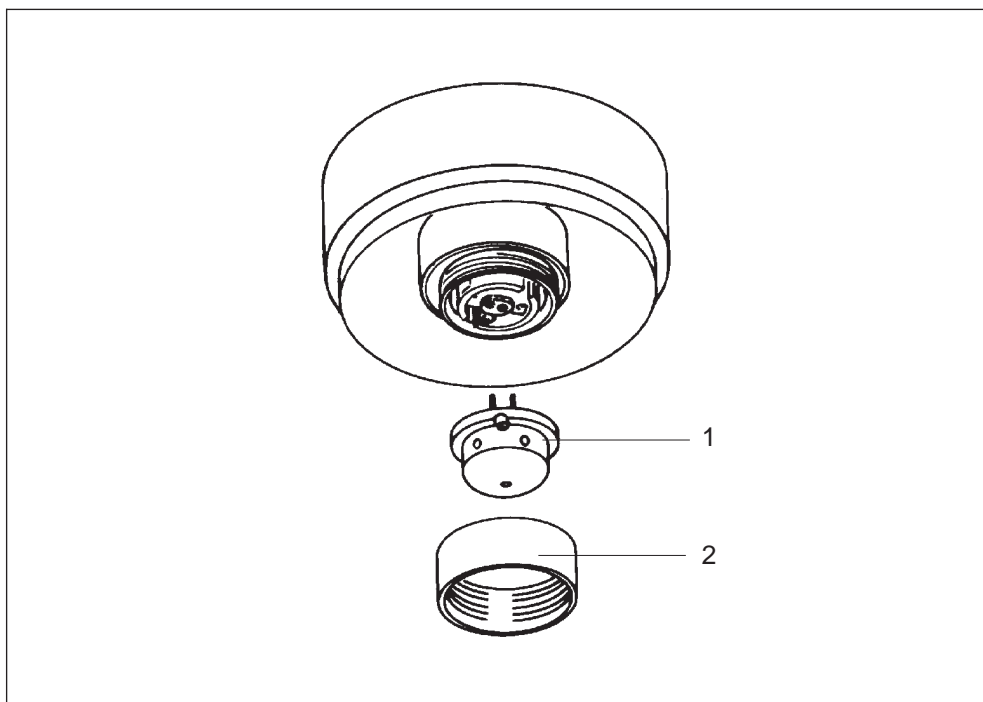
Filament exchange

Fig. 6-3: Filament exchange

- Hold Wehnelt retaining ring (2) with clean glove and unscrew.
- Pull filament holder (1) out of plug contact.
- From below insert exactly precentered cleaned spare filament holder into plug contact.
- Secure filament holder by lightly tightening Wehnelt retaining ring by hand.

**SPECIAL NOTE:**

The filament pins must not be twisted or bent when tightening.

6.3 Anode exchange

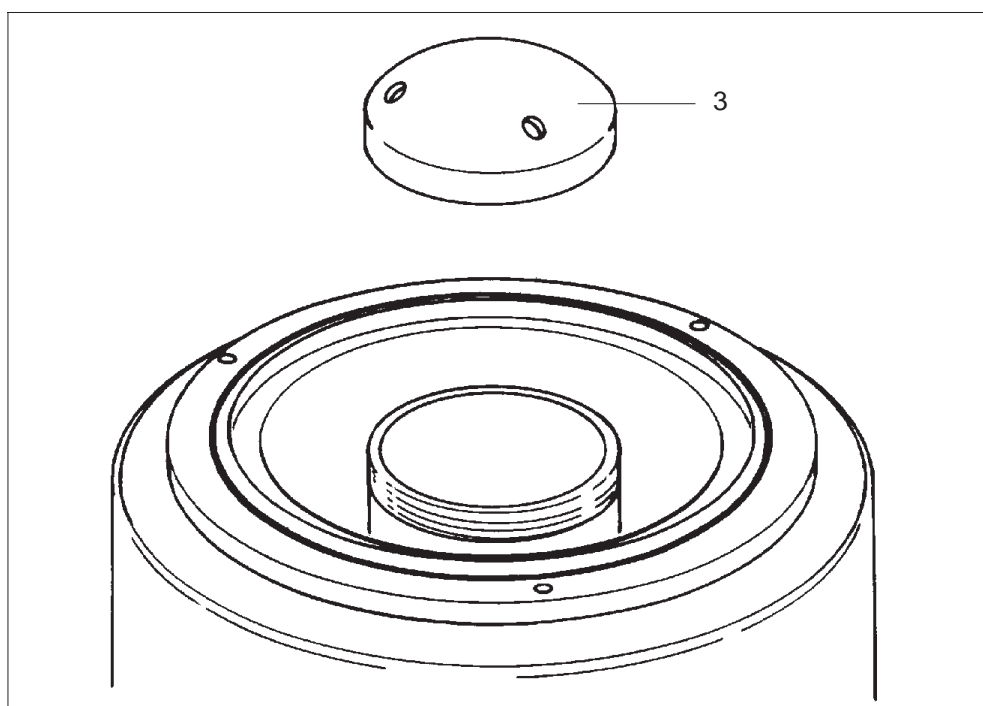


Fig. 6-4: Anode exchange



SPECIAL NOTE:

With filament exchange the anode should always be replaced by a clean one, too.

- With clean glove hold anode (3) on edge and unscrew.
- Install spare anode and lightly tighten by hand.
- With rubber ball blow off dust particles or fibers on filament, anode, O-ring and sealing surface before closing the gun.

6.4 Electrode cleaning

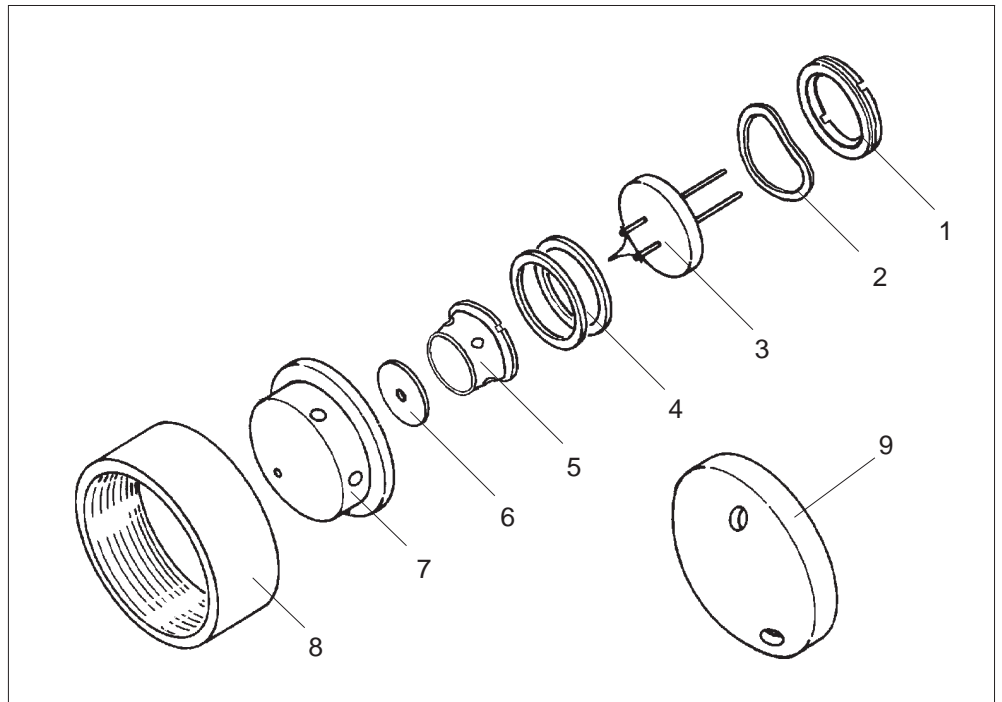


Fig. 6-5: Parts requiring cleaning

The following parts (Fig. 6-5) need cleaning:

- Filament holder (7) with parts 5 and 6.
- Retaining ring (8)
- Anode (9)

The filament holder must be disassembled before cleaning; it consists of the following items:

- Locking ring (1)
- Washer (2)
- Filament (3)
- Spacer rings (4)
- Wehnelt insert (5)
- Wehnelt aperture (6)
- Wehnelt cylinder (7)

The following cleaning agents are required:

- Alcohol and acetone as solvents
- Sidol Stahlglanz for cleaning

Tools:

- Clean cotton

- Lint-free cloth (e.g. linen)
- Wooden sticks of different diameters
- Polishing paper or linen (grain 800 or more)
- Padded tweezers
- Ultrasonic bath with heating. If the bath has no heating, infrared lamp or hot-air cabinet for drying is recommended.
- Stereomicroscope (if available)

Mechanical precleaning

Wehnelt cylinder

- Clean surfaces with Sidol; no contamination and scratches should be visible.



SPECIAL NOTE:

The outer sphere surface and the Wehnelt hole must be treated with special care to prevent leakage current and micro discharges.

- Rinse parts thoroughly in water.
- Remove Sidol residues with cotton soaked in acetone.

Wehnelt insert

- Remove evaporated layers especially on inner surfaces with Sidol. High polish not necessary.

Wehnelt aperture

- Remove evaporated layers with Sidol or polishing paper.
- Polish surfaces and aperture hole with Sidol; no scratches should be visible.
- Clean aperture hole with pointed wooden stick and cotton.

Anode and retaining ring

- Remove evaporated layers, traces of impact and scratches with Sidol and polishing paper.
- Polish surfaces and hole with Sidol; no scratches should be visible.

Spacer rings and locking ring

must be cleaned in ultrasonic bath.

Ultrasonic bath for all parts



SPECIAL NOTE:

Arrange parts in ultrasonic bath so that they are not scratched. This applies in particular to the sphere surface and the hole of the Wehnelt cylinder.

- Take the electrode (Wehnelt or anode) with the tool and put into the glass filled with acetone.
- Rinse parts with acetone in ultrasonic bath for 5 to 10 minutes, which removes any Sidol residues.
- Repeat the procedure in alcohol.
- Take out parts with the tool and dry in hot-air cabinet at max. 100°C or under infrared lamp.
- For assembly place cleaned parts with clean cotton gloves on clean base next to stereomicroscope; polished surfaces facing up!

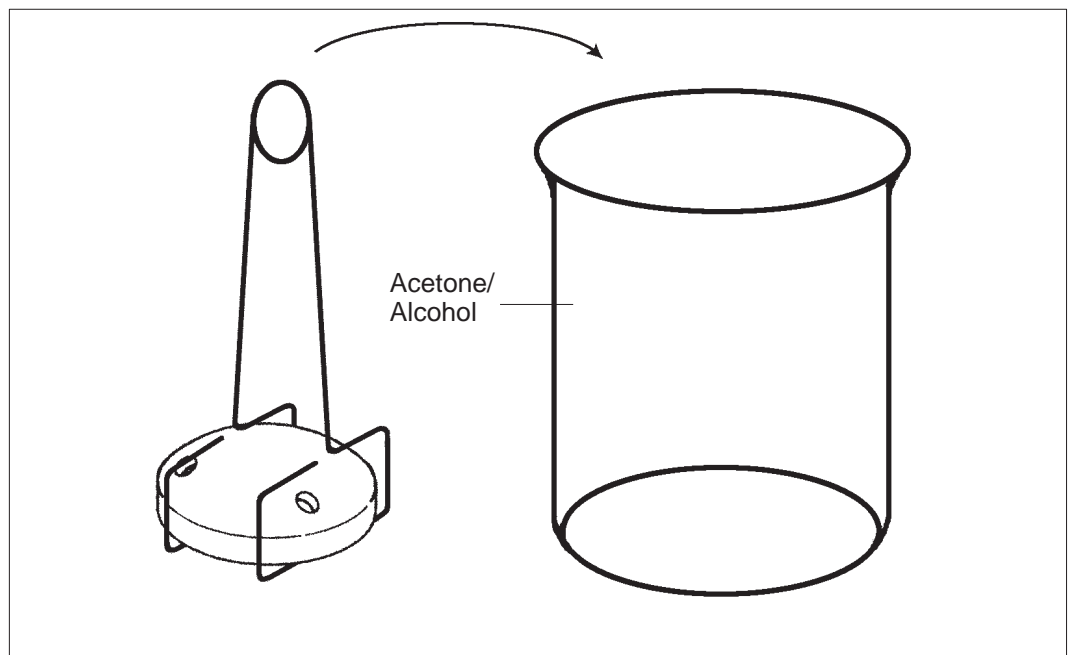


Fig. 6-6: Chemical cleaning of the electrodes

6.5 Assembly of filament holder

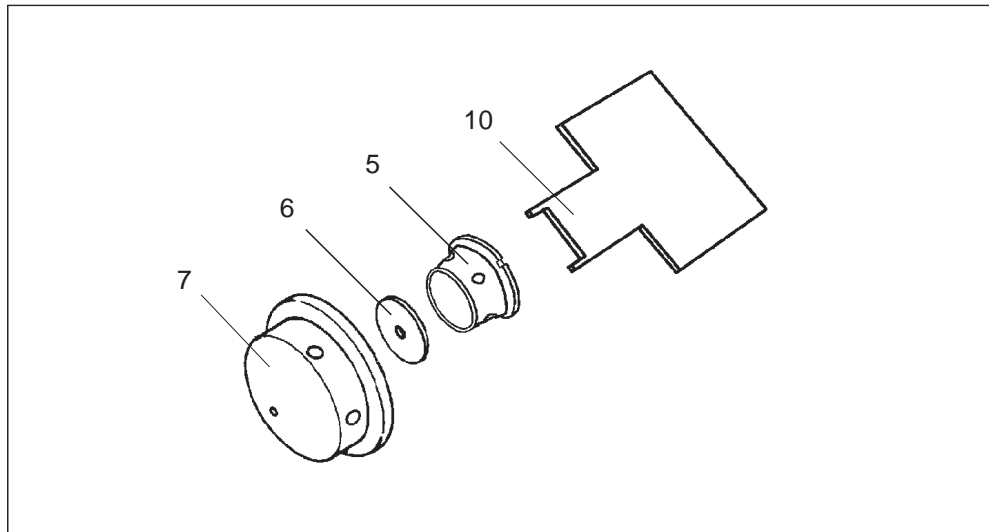


Fig. 6-7: Assembly of filament holder

The assembly of the Wehnelt cylinder is done in 2 steps:

- Assemble parts 5 to 7 according to Fig. 6-6.
- Insert the spacer rings (4) and finish the assembling with parts 1 to 3 (Fig. 6-7).
As long as the same Wehnelt cylinder is used the new hairpin filament needn't to be adjusted in height. The same spacer rings can be taken.

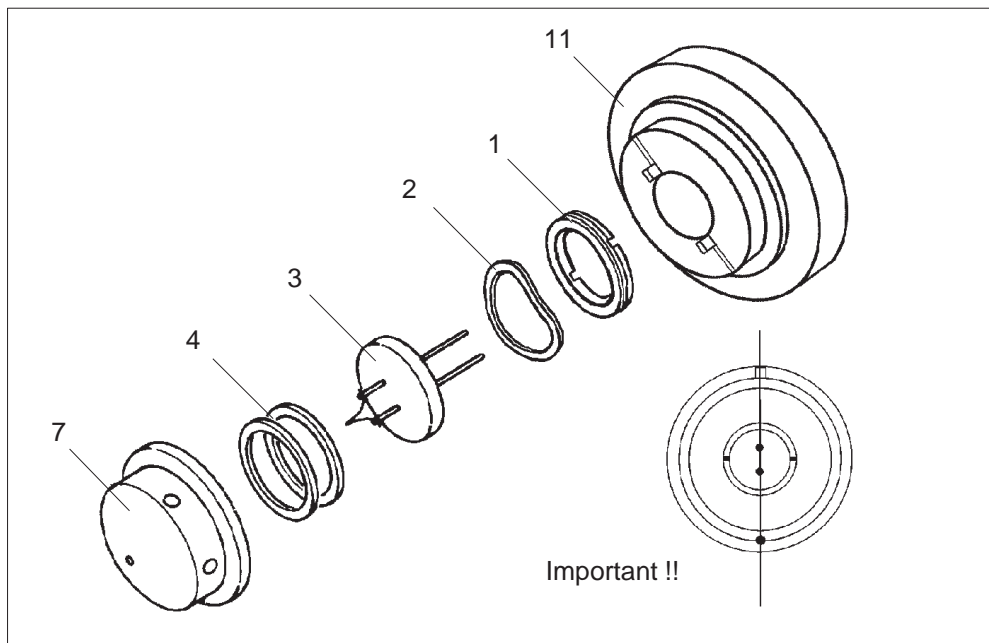


Fig. 6-8: Assembly of filament holder

6.6 Mechanical adjustment of filament

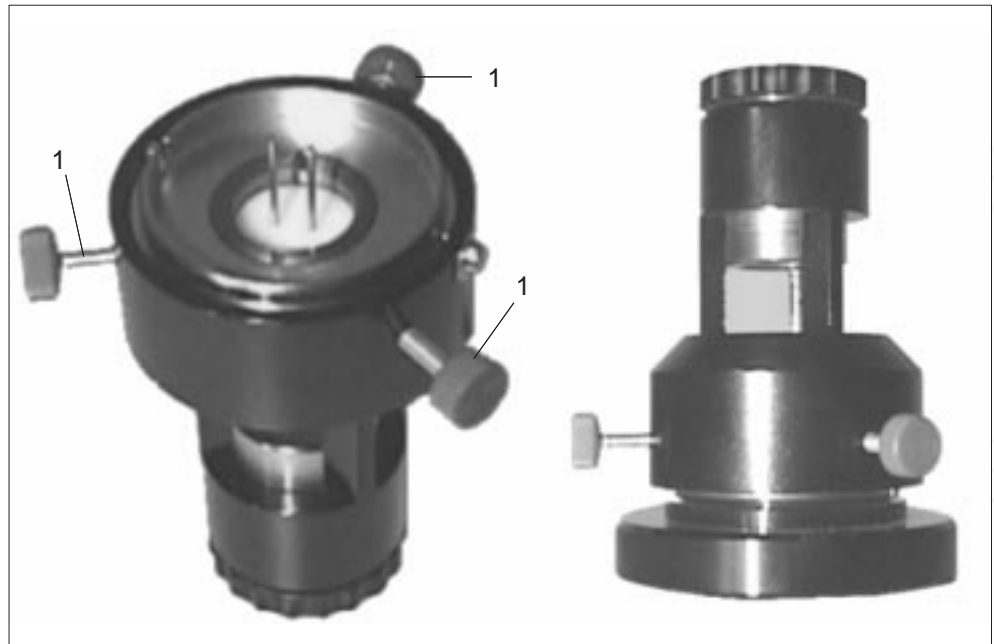


Fig. 6-9: Adjustment device

- Insert the Wehnelt cylinder into the adjustment device. Take care of the orientation.
- Screw in the adjustment screws (1) until they are in contact with the ceramic part of the filament (left).
- Turn the adjustment device upside down and put it on the other part of the adjustment tool (right)
- Adjust the filament with the 3 screws (1) that it is in center of the Wehnelt aperture. Use the magnifier for observation.
- When the filament is centered, keep the lower part und turn the upper part until the final ring is tightened. Check again the filament position.
- Take off the upper part and turn it again upside down (left).
- Loosen the screws (1) until the Wehnelt cylinder can be taken out of the adjustment device.

6.7 Components of the tool kit



Fig. 6-10 Tool kit parts

The tool kit box contains the following parts:

- 1 Holder for electrodes
- 2 Tool for Wehnelt insert
- 3 Aperture key
- 4 Screwdriver for condenser aperture
- 5 Tool for filament centering
- 6 Tool for filament centering
- 7 Fixation screwdriver
- 8 Tweezers
- 9 Socket screw wrench
- 10 Hexagon screwdrivers
- 11 Wehnelt cylinder in box
- 12 Filaments
- 13 Hard wood sticks
- 14 Different o-rings, spacer rings, and aperture rings

6.8 Reactivation after electrode exchange

Pumpdown of the gun

- Push key VENT / EVAC COL in the VAC menu for the standard vacuum system.
- Push key VENT / EVAC GUN in the VAC menu for the extended vacuum system.
Ready state is achieved if the following requirements are fulfilled:
 - Pressure in upper column half less than 2×10^{-5} hPa
 - Pressure in lower column half less than 5×10^{-4} hPa
- Vacuum menu displays *RDY* when the system is ready for operation.

CAUTION:

Strictly follow the order of the steps described below to prevent high-voltage arcs after electrode exchange.

Adjustment of filament type, filament heating current and high voltage

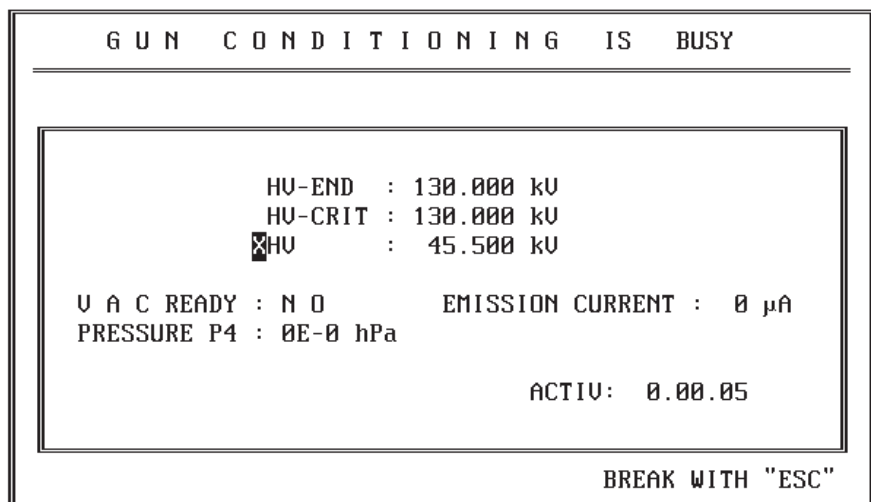
GUN

- Call menu GUN by pushing softkey GUN in main menu.

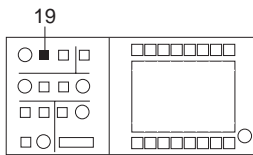
For a detailed description of the menu GUN see section 3.5.

GUN PAR

- Activate GUN PAR menu.
- Push softkey GUN CONDIT. The following window appears:



RESET
LIFETIME

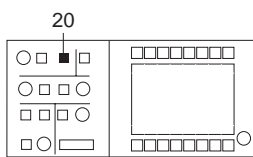


ON FAIL



FILAMENT

FIL.
CURRENT



READY ON



HIGH VOLTAGE



The gun conditioning window displays the HV up to which the gun will be formatted. This value depends on the selected HV step. Any HV step can be selected. The formation is controlled by the vacuum and the emission current which could be emitted by discharging. When the conditioning is finished the microscope is ready for turn-on.

- Select the actual filament type with FIL. SELECT and edit the parameters if necessary.
- Push key RESET LIFETIME and answer enquiry with “Y”.
- LIFE TIME display is set to “0”.
- Return to GUN menu and select the desired HV.

For a detailed description of the menu GUN PAR see section 3.5.1.

Turn-ON

- Turn on filament with key FILAMENT (19) in field GUN (HV still off).
- Activate the function FIL. CURRENT and set the filament current to approx. 3 A. Allow the filament to degas for 1 to 2 min.

- Activate high voltage with key HIGH VOLTAGE (20) in field GUN.

With exactly precentered filament the electron beam will normally be visible on the fluorescent screen.

For exact filament centration see section 5.2.3.

6.9 Care of specimen holders

The very sensitive specimen holder is an important component of the electron microscope and should be handled with care. The front part of the holder from the sapphire bearing to the O-ring seal is in high vacuum. Any contamination will impair the high vacuum, contaminate the specimen and, possibly, cause instability of image or illumination.

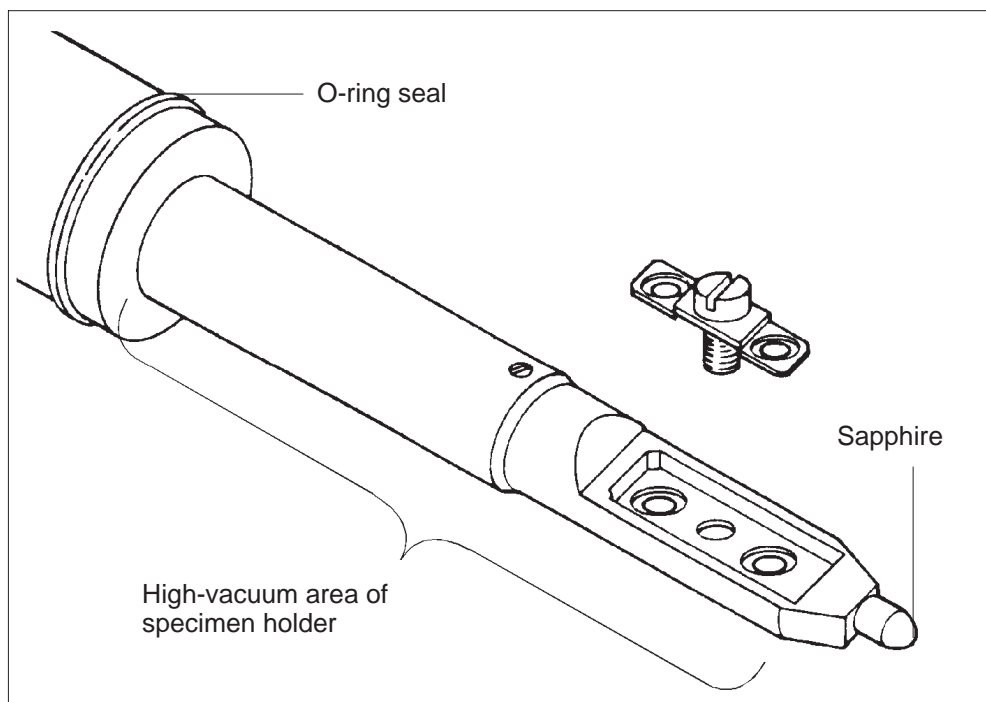


Fig. 6-11: Specimen holder

The O-ring seal is the interface between atmospheric pressure and vacuum. The sealing ring must not be damaged or contaminated. It should be lightly greased (vacuum grease TF 50 HV, CZ ident. no. 101.311). If the ring is too dry, air may penetrate with lock-in. Too much grease causes contamination.

The sealing ring should be cleaned and greased from time to time by rubbing it between fingertips.

The area between sealing ring and sapphire must be absolutely clean. Any contact impairs the vacuum, lengthens the pump down time, contaminates the specimen, and, in element analysis, brings about wrong analytical results.

Cleaning instructions for specimen holder

The specimen holders are generally not or only slightly contaminated and can be cleaned with solvents.

Cleaning:

- Clean clamping bridge in ultrasonic bath.
- As far as O-ring seal clean specimen holder with cotton soaked in acetone. Do not place rod in ultrasonic bath; only if needed shortly immerse it!
- Dry rod by blowing with rubber ball.



SPECIAL NOTE:

The sapphire is glued on the rod tip. Extended treatment with solvents, heating or cleaning in ultrasonic bath may loosen the glue.

For cleaning the special holders (rotary or double tilt rod) see the cleaning instructions by the manufacturers.

6.10 Aperture exchange

6.10.1 Aperture removal

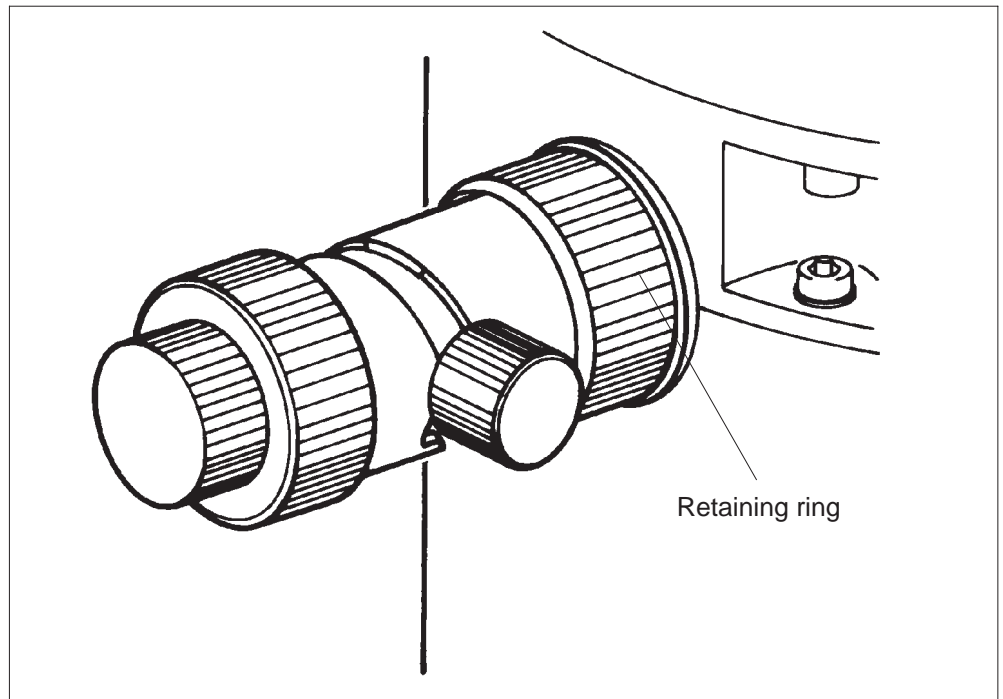


Fig. 6-12: Loosening retaining ring

- Push key VENT / EVAC COL in menu VACUUM.
- Answer enquiry with "Y".
 - The instrument is ventilated.
- Loosen retaining ring on aperture drive (Fig. 6-9).
- Pull aperture drive carefully out of mount.

Assemble in reverse order!

6.10.2

Exchange of objective lens apertures and selector apertures

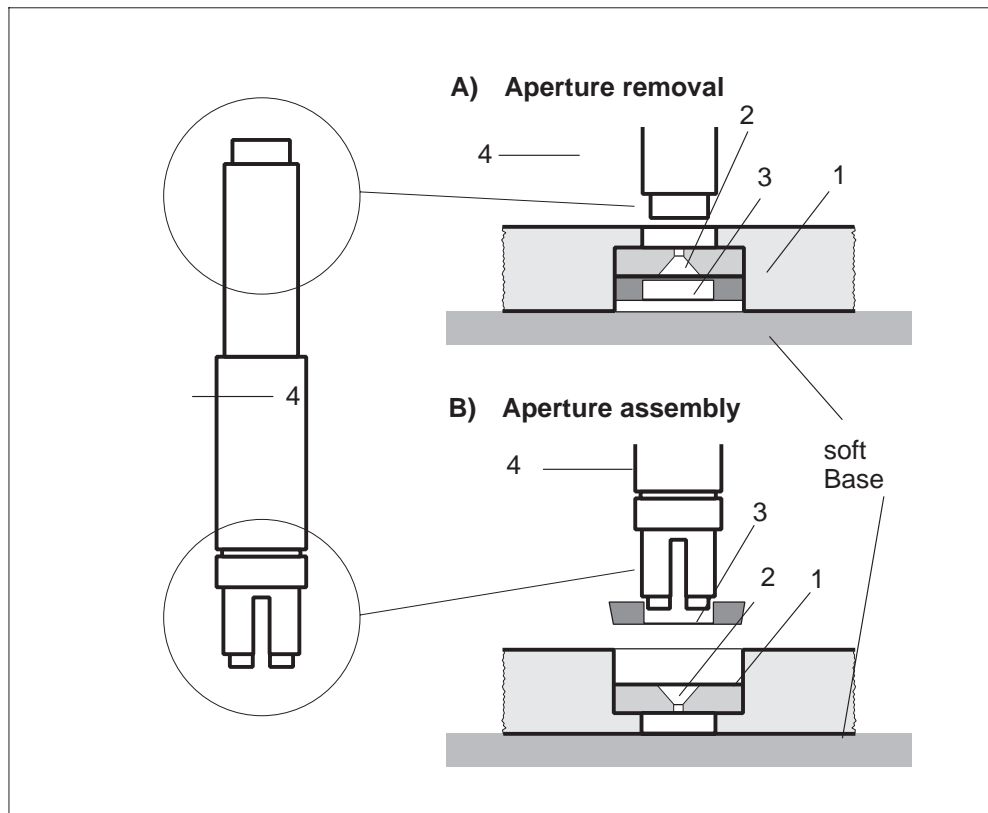


Bild 6-13: Aperture exchange

Aperture removal

- Place aperture holder (1) on clean surface.
- With tool (4) press aperture (2) and spring ring (3) out of aperture holder (Fig. 6-13, A).

**SPECIAL NOTE:**

Contamination of the aperture holder may cause charging and instability of image or illumination! All apertures must then be removed from the aperture holder, the holder itself removed and all parts cleaned. Observe the cleaning instructions (section 6.4, "Ultrasonic bath for all parts")!

Aperture assembly

- Turn aperture holder (1) through 180° and place it on clean surface.
- Insert new apertures (2) (Fig. 6-13).
- Attach spring ring (3) and press down with tool (4) (Fig. 6-13, B).

6.10.3

Condenser aperture exchange

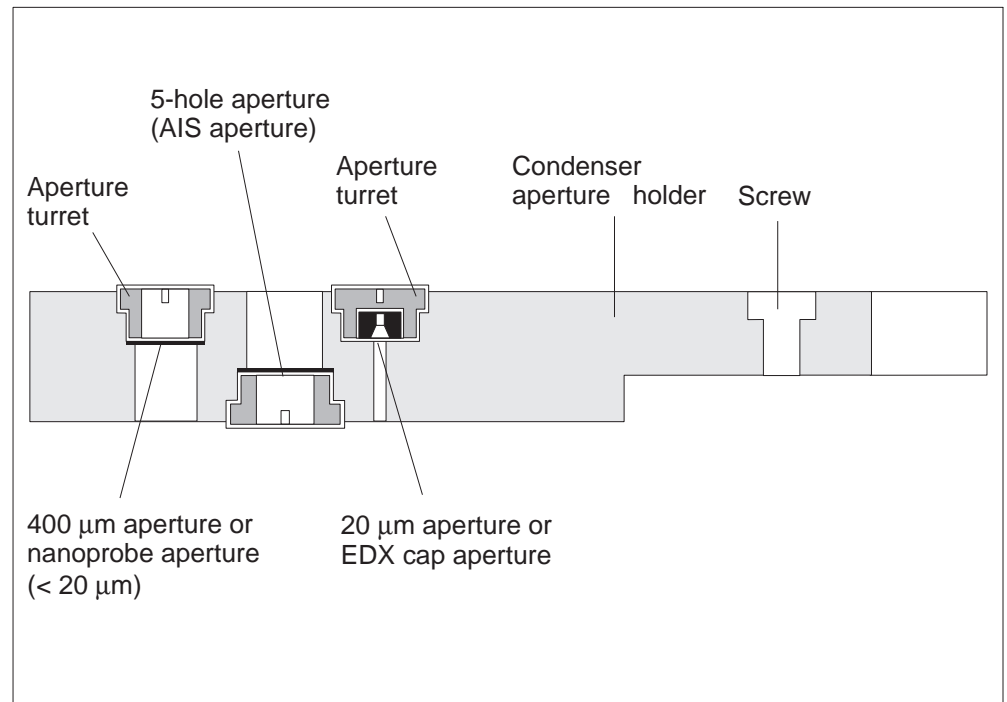


Fig. 6-14: Aperture position

The holder of the condenser aperture has 3 positions of which the one in the middle is for the AIS aperture. The standard equipment includes:

Position 1: 400 μm single-hole molybdenum aperture

Position 2: AIS platinum aperture

Position 3: 20 μm single-hole molybdenum aperture or EDX cap aperture

**SPECIAL NOTE:**

The AIS aperture should be exchanged only by a service engineer because the aperture exchange requires complete alignment of the AIS system.

An aperture with $< 20\mu\text{m}$ diameter is recommended for microbeam diffraction (nanoprobe). It can be accommodated in position 1 or 3.

If the LEO 912 OMEGA is equipped with an EDX analysis system a special "cap aperture" for column collimation is accommodated in position 3.

6.11 Care of vacuum pump (rotary pump)

Oil level and oil color of the rotary pump must be monitored at regular intervals. The oil level gage is at the front of the pump.

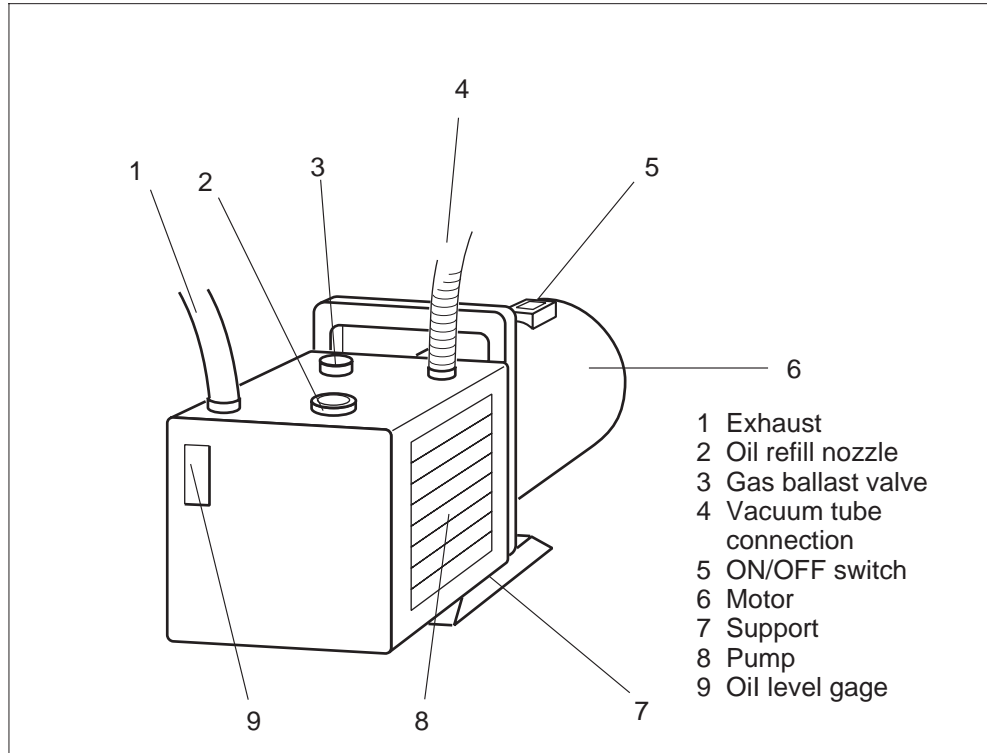


Fig. 6-15: Oil level monitoring

Gage (9) displays oil level and oil color. Refilling is necessary if the level is below "Min".

The oil absorbs water from the air with frequent specimen exchange. The color of the oil changes to gray. If the lock-in/out time is more than 20 - 30s the rotary pump should be switched to gas ballast mode for approx. 30min.

If the pump is in frequent use the oil should be exchanged every 6 months.

For more information see the pump manufacturer's instructions.

6.12 Cleaning the filter mats in the power supply cabinet

Ventilators cool the power electronics in the power supply cabinet of the LEO 912 OMEGA. The filter mats must be cleaned every 1 - 2 months to guarantee full cooling capacity.

“BACK UP ALL” is the last reminder (see section 4.1).

Procedure

- Turn off instrument.
- Pull forward mounting frame of filter mats.
- Take out filter mats.
- Clean mats with vacuum cleaner (rinse and dry).
- Place mats in frame and press down frame.

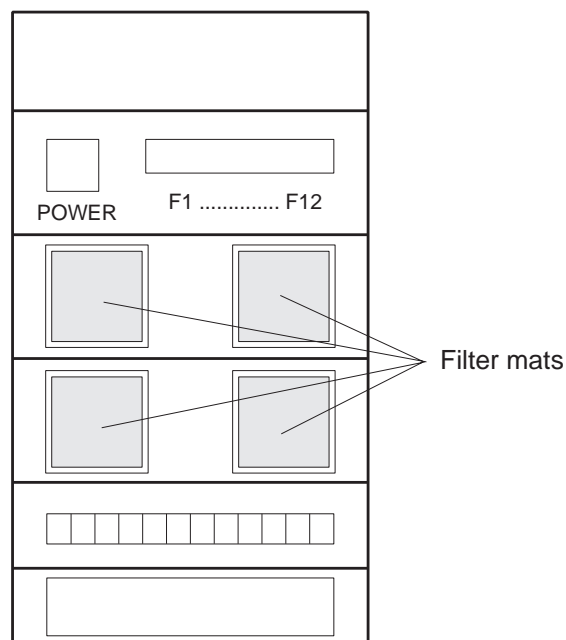


Fig. 6-16: Power supply cabinet of LEO 912 OMEGA

6.13 Preparation of backup floppies

After an selectable number of activations the host computer will automatically call for a backup floppy. As a general rule, a backup should be made at least once a week.

The backup floppy is required in case of hard-disk failure or read error. The backup copy should be up to date concerning the storage of counts such as film number, filament hours, etc. and all alignment states.

- Call menu START.
- Load floppy in disk drive.
- Format new floppy by pushing key FORMAT DISK.
- Push softkey BACK UP ALL.

All software files are automatically backed up. Further information is displayed. Backup floppies may be used several times; they are automatically overwritten.



Supplements

7.1 Remote Commands

Command list for LEO 906E, LEO 910, LEO 912 OMEGA, LEO 912AB OMEGA and LEO 922

Version: V3.21 valid for all versions since November 1998

Interface

Remote is possible on "COM1" and "COM2" .

The interfaces are configured as follows:

Baudrate : 2400 ... 19200, Datenbit: 7 ... 8, Stopbit: 1 ... 2, Parity: No,
No hand shake

Description

Commands can be processed as a single command or as a sequence of commands up to 127 characters.

After every command or sequence of command there must be a command end code:

"J" = 5Dh = 93d

As confirmation for the receipt of a command or sequence of commands and for the start of processing there

is a confirmation code:

"^" = 5Eh = 94d

During command processing error codes are transmitted.

After processing of the sequence of commands a finished code is returned:

"_" = 5fh = 95d

The processing time of each command is different. It is < 200 ms , if not defined to a other value in the command description

Example

Send to EM: "R1T001T003R0J"
(reading command into EM)
(return of confirmation)

Send to external system: "^"
(processing of command in EM)
(transmission of error codes)
(clearing of input puffer)
(return of finished code)

Send to external system: "_"
(waiting for next command)

This example selects remote operation (R1), then imaging mode (T001), then illumination mode TEM (T003) and then switches off remote operation.

7.1.1 GET commands

G001 GET_MODE:

RECEIVE :G001xxxxx(5)

```

|||||
|||| ILL_BF_DF      : 0 = BRIGHTFIELD
||||               : 1 = DARKFIELD
|||| ILL_MODE       : 0 = TEM
||||               : 1 = SPOT
||| FILTER_MODE     : 0 = IMAGE
|||                 : 1 = SPECTRUM
| IMAGE_MODE        : 0 = IMAGE
|                   : 1 = DIFFRACTION
MAG-MODE           : 0 = MAG
                   : 1 = LOW MAG

```

G002 GET_FOCUS_MODE:

RECEIVE: G002x

```

|
| FOCUS_STEP        : 0 = COARSE
|                   : 1 = FINE

```

G003 GET_IMAGE_STIG_SHIFT_MODE:

RECEIVE: G003x(1)

```

|
| IMAGE_STIG_SHIFT_MODE 0 = I_SHIFT
|                       : 1 = I_STIG

```

G004 GET_ILL_TILT_SHIFT_DEFL_STIG_MODE:

RECEIVE: G004xx(2)

```

||
| TILT_SHIFT_MODE      0 = SHIFT
|                       : 1 = TILT
|
| DEFL_STIG_MODE       0 = STIG
|                       : 1 = DEFL

```

G005 GET_LEO_910_PROGRAM_VERSION:

RECEIVE: G005xxxxxxxxzzzz(12)

```

|   |   |
|   |   | SERIEN_NUMMER
|   |   | VERSION
|
| EM_TYP           0 = LEO_910
|                   : 1 = LEO_912

```

G006 GET_STATUS_1:

RECEIVE: G006xxxxxxxxxx(10)

```

|||||||
|||||||MDF: 0=OFF,1=ON
|||||||AIS: 0=OFF,1=ON
|||||||HV: 0=OFF,1=ON
|||||||FILAMENT: 0=OFF,1=ON
|||||PN_TV: 0=OFF,1=ON
|||DETECTOR_SHUTTER:0=OFF,1=ON
|||SHUTTER: 0=OFF,1=ON
||BEAM_BLANKER: 0=OFF,1=ON
|SMALL_SCREEN_POS: 0=DOWN,1=UP
LARGE_SCREEN_POS:0=DOWN,1=UP

```

G033 GET_SPEC_MAG_FINE_MODE:

RECEIVE: G033x(1)

```

|
SPEC_MAG_FINE_MODE: 0=AUS,1=AN

```

G043 GET_OVERVIEW_MODE:

RECEIVE: G043x(1)

```

|
OVERVIEW_MODE: 0=AUS,1=AN

```

G100 GET_MAG_POINTER:

RECEIVE: G100xx(2)

RANGE: COARSE :

LEO910

MODE: LM/IMAGE xx : 1...15

LM/DIFFR xx : 1...28

MAG/IMAGE xx : 1...28

MAG/DIFFR xx : 1...15

LEO912

MODE: LM/IMAGE xx : 1...15

LM/DIFFR xx : 6...28

MAG/IMAGE xx : 6...28

MAG/DIFFR xx : 1...15

RANGE: FINE: xx : -9...19

G101 **GET_ILLUMINATION_APERTURE:**
RECEIVE: G101xx(2)
RANGE: COARSE xx : 1...30
FINE xx : -9...19

G102 **GET_SPECTRUM_MAG:**
RECEIVE: G102xx(2)
RANGE: FINE x : -9...49
COARSE x : 1...10

G103 **GET_HT_POINTER:**
RECEIVE: G103x(1)
RANGE: x : 1...6 FÜR EM910
x : 3...6 FÜR EM912

G106 **GET_USER_PROG_POINTER:**
RECEIVE: G106x(1)
RANGE: e.g.: x : 1...8

G107 **GET_SHUTTER_TYPE:**
RECEIVE: G107x(1)
RANGE : 0 : NO-SHUTTER
1 : BEAM-BLANKER
2 : CAMERA-SHUTTER
3 : FAST-PS-SHUTTER
4 : SLOW-PS-SHUTTER

G116 **GET_MDF_ILLUMINATION_OFFSET:** (since Nov. 1998)
RECEIVE: G116xxxxxyyyy(8)
RANGE: x : -681...683

G117 **GET_MDF_IMAGE_OFFSET:** (since Nov. 1998)
RECEIVE: G117xxxxxyyyy(8)
RANGE: x : -681...683
y : -681...683

G118 **GET_MDF_TILT_OFFSET:** (since Nov. 1998)
RECEIVE: G118xxxxxyyyy(8)
RANGE: x : -149...150
y : -149...150y : -681...683

G119 **GET_MDF_DESCAN_OFFSET:** (since Nov. 1998)

RECEIVE: G119xxxxyyy(6)

RANGE: x : -50...50

y : -50...50

G150 **GET_MAG_VALUE:**

RECEIVE: G150xxxxxxx(6)

RANGE: e.g.: x :10...500000

G151 **GET_HIGH_VOLTAGE_VALUE:**

RECEIVE: G151xxxxxxx(6)

RANGE: e.g.: x : 0...120000

G152 **GET_SPECTRUM_MAG_VALUE:**

RECEIVE: G152xxxx(4)

RANGE: e.g.: x : 40...315

G200 **GET_DELTA_E:**

RECEIVE: G200xxxxxx(5)

RANGE: x : 0...12500

G201 **GET_EMISSION_CURRENT:**

RECEIVE: G201xxx(3)

ADJUSTABLE:

RANGE: e.g.: xxx : 000 ...200 μ A

NON ADJUSTABLE:

6-STEPS

RANGE: e.g.: xxx : 1..6

B:Z:W

24-STEPS

RANGE: e.g.: xxx : 1..24

G202 **GET_FOCUS:**

RECEIVE: G202xxxx(4)

RANGE: e.g.: x : 0...4095

G203 **GET_C3_FOCUS:**

RECEIVE: G203xxxx(4)

RANGE: e.g.: x : 0...4095

G204 **GET_IMAGE_VAL:**
RECEIVE: G204xxxxxyyyy(8)
RANGE: e.g.: x,y : 0...4095

G205 **GET_ILL_VAL:**
RECEIVE: G205xxxxxyyyy(8)
RANGE: e.g.: x,y : 0...4095

G206 **GET_FILTER_VAL:**
RECEIVE: G206xxxx(4)
RANGE: e.g.: x : 0...4095

G209 **GET_MIS_APERTURE:** (since Nov. 1998)
RECEIVE: G209x(1)
RANGE: e.g.: x : 0...4

G211 **GET_EMISSION_CURRENT_LIMIT:**
RECEIVE: G211xxxxxyyyy(8)
ADJUSTABLE:
RANGE: e.g.: xxx : 000 ...200 μ A
NON ADJUSTABLE:
6-STUFIG
RANGE: e.g.: xxx : 1..6
B:Z:W
24-STUFIG
RANGE: e.g.: xxx : 1..24

G212 **GET_FOCUS_LIMIT:**
RECEIVE: G212xxxxxyyyy(8)
RANGE: e.g.: x : 0...4095

G213 **GET_C3_FOCUS_LIMIT:**
RECEIVE: G213xxxxxyyyy(8)
RANGE: e.g.: x,y : 0...4095

G214 **GET_IMAGE_VAL_LIMIT:**
RECEIVE: G214xxxxxyyyy(8)
RANGE: e.g.: x,y : 0...4095

G215 **GET_ILL_VAL_LIMIT:**
RECEIVE: G215xxxxxyyyy(8)
RANGE: e.g.: x, y : 0...4095

```

G216 GET_FILTER_VAL_LIMIT:
      RECEIVE: G216xxxxxyyyy(8)
      RANGE: e.g.: x, y : 0...4095

G220 GET_ECO_OFFSET_VAL:
      RECEIVE: G220xxxxxyyyy(10)
      RANGE: e.g.: x,y : -1500...1500

G221 GET_STEM_XY_POS:
      RECEIVE: G221xxxxxyyyy(8)
      RANGE :      x = 0.. 255
                y = 0...255

G299 GET_DIGITAL_CURRENT_VALUES:
      RECEIVE: G299x..x(49*5)
      RANGE: e.g.: x : 0...4095

      !!! DO NOT USE !!!
      DISPLAY OF THE DIGITAL CURRENT VALUES
      WHICH EQUALIZE E/O-CURRENTS.

G300 GET_GON_POSITION:
      RECEIVE: G300xxxxxxxxxyyyyyyyzzzzzzzztttttttt(32)
      RANGE: x,y,z,t : -1000000...+1000000

G301 GET_POSITION_STATUS:
      RECEIVE: G301x(1)
      RANGE: x          0 =   GONIOMETER NOT READY
                        TO RECEIVE NEW POSITIONS.
                        1 =   GONIOMETER READY TO
                        RECEIVE NEW POSITIONS.

G302 GET HOLDER POSITION:
      RECEIVE: G302xxxyyyyyy(8)
      RANGE: x:???,   y: ???
                KENNUNG ZUS.-AXIS

G310 GET_EXPOSURE_TIME:
      RECEIVE: G310xxxxxx(5)
      RANGE: x :   s 0.3 c<0.2 ?—

G311 GET_EXPOSURE_NO:
      RECEIVE: G311xxxxxxx(6)
      RANGE: x : 0...999999

```



```

G312 GET_EXPOSURE_CURRENT:
      RECEIVE: G312xxxxxxx(6)
      RANGE: e.g.: x : 36E-08

G313 GET_CAMERA_DATAFIELD:
      RECEIVE: G313x...x(64)

G314 GET_CAMERA_COMMENT:
      RECEIVE: G314x...x(120)

G315 GET_CAMERA_FILM_DATA:
      RECEIVE: G315xxxxxxxxxx(8)
              || | FILM_DENS(3)
              || DATA_DENS(2) 00 = IF
              | CAM_TYPE : MM35
              |DENS_SELECT(1)  A = DENS_A
              | B = DENS_B
              | 0 = IF
              | CAM_TYPE : MM35
              FILM_SUPPLY(2)

G320 GET_ELECTRON_DETECTOR:
      RECEIVE: G320xxxxxxx(6)
              || |
              || HT- PMT(4)
              |STATUS : 0 = NORMAL
              | 1 = OVERLOADED
      SELECT: 0 = CAGE
              1 = PMT

G350 GET_SLIT:
      RECEIVE: G350x
              |
      SELECT: 0 = SLIT-STEP 0
              1 = SLIT-STEP 1
              2 = SLIT-STEP 2
              3 = SLIT-STEP 3
              4 = SLIT-STEP 4
              5 = SLIT-STEP 5
              6 = SLIT-STEP 6

```

7.1.2 SET Commands

Changing microscope conditions with parameters

S100 SET_MAG_POINTER:

SEND: S100xx(2)

RANGE: COARSE:

LEO 910 :

MAG/IMAGE : 1 - 28

MAG/DIFFR : 1 - 15

LM/IMAGE : 1 - 15

LM/DIFFR : 1 - 28

LEO 912 :

MAG/IMAGE : 6 - 28

MAG/DIFFR : 1 - 15

LM/IMAGE : 1 - 15

LM/DIFFR : 6 - 28

RANGE: FINE xx : -9...19

The fine value is an offset to the coarse step if this mode is activated.

S101 SET_ILL_APERTURE:

SEND: S101xx(2)

RANGE: COARSE xx : 1...30

FINE xx : -9...19

S102 SET_SPECTRUM_MAG:

SEND: S102xx(2)

RANGE: SPECTRUM/SPECTRUM MODE

COARSE xx : 1...10

FINE xx : -9...19

RANGE: SPECTRUM/IMAGE MODE

COARSE xx : 13...16

13 : * 1.

14 : * 0.75

15 : * 0.25

16 : * 0.1

FINE xx : -9...49

For using this command the OVERVIEW mode has to be activated.

```
S103 SET_HT:
      SEND: S103x(1)
      RANGE LEO 910 : 2...6
      RANGE LEO 912 : 3...6
                                1 : HT = 20 kV
                                2 : HT = 40 kV
                                3 : HT = 60 kV
                                4 : HT = 80 kV
                                5 : HT =100 kV
                                6 : HT =120 kV

S106 SET_USER_PROG:
      SEND: S106x(1)
      RANGE : 1 - 8

S107 SET_SHUTTER_TYPE:
      SEND: S107x(1)
      RANGE :
                                0 : NO-SHUTTER
                                1 : BEAM-BLANKER
                                2 : CAMERA-SHUTTER
                                3 : FAST-PS-SHUTTER
                                4 : SLOW-PS-SHUTTER

S116 SET_MDF_ILLUMINATUIN_OFFSET: (since Nov. 1998)
      SEND: S116xxxxxyyyy(8)

      RANGE: x : -681...683
            y : -681...683

S117 SET_MDF_IMAGE_OFFSET: (ab 10.1998)
      SEND: S117xxxxxyyyy(8)

      RANGE: x : -681...683
            y : -681...683

S118 SET_MDF_TILT_OFFSET: (ab 10.1998)
      SEND: S118xxxxxyyyy(8)

      RANGE: x : -149...150
            y : -149...150
```

S118 **SET_MDF_TILT_OFFSET:** (since Oct. 1998)
SEND: S118xxxxxyyyy(8)

RANGE: x : -149...150
y : -149...150

S119 **SET_MDF_DESCAN_OFFSET:** (since Oct.1998)
SEND: S119xxxxyyy(6)

RANGE: x : -50...50
y : -50...50

S200 **SET_DELTA_E:**
SEND: S200xxxxxx(5)
RANGE : 1 - 12500

S201 **SET_EMISSION_CURRENT:**
SEND: S201xxx(3)
RANGE : HT = 20 kV , 0 - 200 μ A
HT = 40 kV , 0 - 150 μ A
HT = 60 kV , 0 - 100 μ A
HT = 80 kV , 0 - 80 μ A
HT =100 kV , 0 - 60 μ A
HT =120 kV , 0 - 50 μ A

S202 **SET_FOCUS:**
SEND: S202xxxx(4)

S203 **SET_C3_FOCUS:**
SEND: S203xxxx(4)

S204 **SET_IMAGE_VAL:**
SEND: S204xxxxxyyyy(8)

S205 **SET_ILL_VAL:**
SEND: S205xxxxxyyyy(8)

S206 **SET_FILTER_VAL:**
SEND: S206xxxx(4)

S207 SET_BEAM_TIME:

SEND: S207xxxx(4)

RANGE : 0...5000 ms.

This function assumes an active BEAM BLANKER. It deactivates the BEAM BLANKER and reactivates it after the transmitted time is over.

S208 SET_DEFOCUS_VAL:

SEND: S208xxxxxx(5)

RANGE : -2047...2047.

Setting of a defined under- or overfocus.

One step equalizes 4nm.

S209 SET_MIS_APERTURE_:

SEND: S209x(1)

RANGE : 0...4.

AIS and MIS mode have to be activated.

S210 SET_DELAY_TIME:

SEND: S210xxxx(4)

RANGE : 0...5000.

S220 SET_ECO_OFFSET_VAL:

SEND: S220xxxxxxxxxyyyy(10)

RANGE : X = Y = +,- 1500

S221 SET_STEM_XY_POS:

SEND: S221xxxxxxxxxyyyy(8)

RANGE : x = 0.. 255

y = 0...255

S300 SET_GON_POSITION:

SEND: S300xxxxxxxxxyyyyyyyzzzzzzzztttttttt(32)

RANGE : X = Y = Z = +,- 1000000

T = +,- 0600000

z.B.: S300-1000000-0020000+00000000+00000000

S302 SET HOLDER POSITION:

SEND: S302xyyyyyyy(8)

| |

| ZUS. axis(6)

IDENTIFICATION(2)

```

RANGE :
      ADD. ROTATION
                YYYYYY
                ||| |
                ||| 30h
                ||ROT. 0 - 360
                |30h
                SIGN +

```

EXAMPLE:

```

S302î +03600           = 360°
S302î +00050           = 5°

```

ADD. TILT

```

                YYYYYY
                ||
                |FOR ADD. TILT -28000...+28000
                SIGN +,-

```

EXAMPLE:

```

S302f +28000           ;= +28°
S302f -28000           ;= -28°

```

The holder is detected during the program start or if you are moving into the GON menu.

The movement of the axis can't be detected via GET_POSITION_STATUS

```

IDENTIFICATION:      xx = E8h,20h for add. tilt axis
                    xx = 232d,32d for add. tGudrunilt axis
                    xx = EEh,20h für zus. Rot. axis
                    xx = 238d,32d für zus. Rot. axis

```

S303 SET_GON_X_POSITION:

```

      SEND:  S303xxxxxxxx(8)
      RANGE : X = +,- 100000

```

S304 SET_GON_Y_POSITION:

```

      SEND:  S304xxxxxxxx(8)
      RANGE : Y = +,- 100000

```

S305 SET_GON_Z_POSITION:

```

      SEND:  S305xxxxxxxx(8)
      RANGE : Z = +,- 100000

```

```
S306 SET_GON_T_POSITION:
      SEND: S306xxxxxxxx(8)
      RANGE : T = +,- 0600000

S307 SET_GON_ROTATION:
      SEND: S307x(1)
      RANGE : x = 0..3
            X = 0 : normal mode
            X = 1 : 90°
            X = 2 : 180°
            X = 3 : 270°
            X = 4 : keine Drehung

S308 SET_GON_MIRROR:
      SEND: S308x(1)
      RANGE : x = 0..2
            x = 0 : normal mode
            x = 1 : Mirror X-axis (X*(-1)-> X;Y -> Y)
            x = 2 : Mirror Y-axis (X -> X;Y*(-1)->Y)
            x = 0 : No mirror

S310 SET_GON_TRACKBALL_MODE: (since Apr. 1998)
      SEND: S310x(1)
      RANGE : x = 0..7
            (x = 0 : Trackball without function)
            (x = 1 : X/Y Goniometer)
            (x = 2 : Z - axis)
            (x = 3 : T - axis)
            (x = 4 : R - axis)
            (x = 5 : T' - axis)
            (x = 6 : Mot_aperture # 1)
            (x = 7 : Mot_aperture # 2)

S311 SET_APERTURE: (since Apr. 1998)
      SEND: S311x(1)
      RANGE : x = 0..3
            x = 0 : no aperture
            x = 1 : aperture # 1
            x = 2 : aperture # 2
            x = 3 : aperture # 3

S316 SET_FIX_EXP_TIME:
      SEND: S316xxxxx(4)
      RANGE : 0.20 - 300
```

S317 **SET_FILM_DENSITY:**
SEND: S317xxx(3)
RANGE : 0.1 - 99

S318 **SET_FREE_INPUT:**
SEND: S318xxxxxxxxxxxxxxxxxxxx(16)

S319 **SET_PN_CHANNEL_SWITCH:**
SEND: S319xy(2)
||
|Switch 0 = OFF
|Switch 1 = ON
Channel : 1,2,6,7,8
Switch for free pneumatic channels.
!! Be careful, no security implemented !!

S320 **SET_PMT_VOLTAGE:**
SEND: S320xxx(3)
RANGE : 250 - 800 V

S321 **SET_PMT_TIME_CONSTANT:**
SEND: S321x(1)
RANGE : 1 - 4
1 = 0.001s
2 = 0.1s
3 = 0.3s
4 = 1s

S323 **SET_GON_X_POSITION_DELTA:** (since Jul. 1998+Eprom)
SEND: S323xxxxxx(5)
RANGE : X = +,- 1000

S324 **SET_GON_Y_POSITION_DELTA:** (since Jul. 1998+Eprom)
SEND: S324xxxxxx(5)
RANGE : Y = +,- 1000

S325 **SET_GON_Z_POSITION_DELTA:** (since Jul. 1998+Eprom)
SEND: S325xxxxxx(5)
RANGE : Z = +,- 1000

S326 **SET_GON_T_POSITION_DELTA:** (since Jul. 1998+Eprom)
SEND: S326xxxxxx(5)
RANGE : T = +,- 1000


```
S350 SET_SLIT:
      SEND:   S350x(1)
!! works only with SLIT-Aperture !!

      RANGE:   0..6

              0 = SLIT-STEP 0
              1 = SLIT-STEP 1
              2 = SLIT-STEP 2
              3 = SLIT-STEP 3
              4 = SLIT-STEP 4
              5 = SLIT-STEP 5
              6 = SLIT-STEP 6
```

7.1.3 Task commands

Changing microscope conditions without parameters

```
T001      SELECT_IMAGE_MODE
T002      SELECT_DIFFR_MODE
T003      SELECT_ILL_MODE_TEM
T004      SELECT_ILL_MODE_SPOT
T005      SELECT_MAG_MODE
T006      SELECT_LM_MODE
T007      CALIBARTING_OBJECTIVE
T008      SELECT_FOCUS_FINE_MODE
T009      SELECT_FOCUS_COARSE_MODE
T010      SELECT_IMAGE_STIG_MODE
T011      SELECT_IMAGE_SHIFT_MODE
T012      SELECT_ILL_STIG_MODE
```

T013	SELECT_ILL_DEFL_MODE
T014	SELECT_ILL_TILT_MODE
T015	SELECT_ILL_SHIFT_MODE
T016	MDF_ON:
T017	MDF_OFF
T018	DARKFIELD_ON
T019	DARKFIELD_OFF
T020	CON_ILL_ON
T021	CON_ILL_OFF
T022	AIS_ON
T023	AIS_OFF
T024	BEAM_BLANKER_ON
T025	BEAM_BLANKER_OFF
T026	FILTER_IMAGE
T027	FILTER_SPEC
T028	FILTER_SHIFT
T029	FILTER_FOCUS
T030	SELECT_DETECTOR_CAGE
T031	SELECT_DETECTOR_PMT
T032	RESET_PMT_OVERLOAD:
T033	SELECT_SPEC_MAG_FINE
T034	SELECT_SPEC_MAG_COARSE

T035	SELECT_ill_APERTURE_FINE
T036	SELECT_ill_APERTURE_COARSE
T037	MIS_ON
T038	MIS_OFF
T039	SELECT_MAG_FINE
T040	SELECT_MAG_COARSE
T041	CLOSE_DETECTOR_SHUTTER
T042	OPEN_DETECTOR_SHUTTER
T043	SELECT_SPECTRUM_OVERVIEW_MODE_ON
T044	SELECT_SPECTRUM_OVERVIEW_MODE_OFF
T045	SELECT_ECO_OFFSET_MODE_ON
T046	SELECT_ECO_OFFSET_MODE_OFF
T047	SET_IMAGE_ROTATION_ON
T048	SET_IMAGE_ROTATION_OFF
T049	SELECT_PEELS_MODE_ON
T050	SELECT_PEELS_MODE_OFF
T051	CALIBRATE_MAGNIFICATION:
T052	SET_STEM_SPOT_ON
T053	SET_STEM_SPOT_OFF
T054	HT_FILTER_MAGNETIC RESET

T208	RESET_DEFOCUS_VAL	
T210	RESET_OBJECTIVE_WOBLER	(since Apr. 1998)
T211	SET_OBJECTIVE_WOBLER	(since Apr. 1998)
T212	SET_ILL_SHIFT	(since Jul. 1998)
T213	SET_ILL_TILT	(since Jul. 1998)
T214	SET_ILL_STIG	(since Jul. 1998)
T215	SET_FOCUSKNOB_ON_Z_AXIS	(since Jul. 1998) (!GON EPROM!)
T216	SET_FOCUSKNOB_ON_FOCUS	(since Jul. 1998)
T220	TOGGLE_MDF_FREE_PARALLEL	(since Oct. 1998)
T222	TOGGLE_MDF_DIRECTION	(since Oct. 1998)
T224	RESET_MDF_OFFSET	(since Oct. 1998)
T300	EXPOSURE	
T301	SELECT SMALL_SCREEN	
T302	SELECT CAMERA_COLLECTOR	
T303	SELECT CAMERA_DENS_A	
T304	SELECT CAMERA_DENS_B	
T305	SELECT CAMERA_AUTO_TIME	
T306	SELECT CAMERA_FIX_TIME	
T307	CLOSE_SHUTTER	
T308	OPEN_SHUTTER	
T309	SMALL_SCREEN_UP	

T310	SMALL_SCREEN_DOWN
T311	LARGE_SCREEN_UP
T312	LARGE_SCREEN_DOWN
T313	WOBBLE_HV_ON:
T314	WOBBLE_HV_OFF
T315	FILAMENT_ON
T316	FILAMENT_OFF
T317	FREE_EXPOSURE_ON
T318	FREE_EXPOSURE_OFF
T319	FREE_CAMERA_TRANSPOT_MM35
T320	PN_TV_ON
T321	PN_TV_OFF

A large, stylized number 8 with a white outline and a black shadow effect, positioned in the upper right quadrant of the page.

**Introduction to
Imaging Electron Energy
Loss Spectroscopy**

Table of contents

8	Introduction to Imaging Electron Energy Loss Spectroscopy	
8.1	General	8-3
8.2	Elastic and inelastic scattering processes	8-4
8.3	Elastically scattered electrons	8-5
8.4	Inelastically scattered electrons	8-6
8.5	Multiply scattered electrons	8-7
8.6	The electron energy loss spectrum	8-8
8.6.1	Range around 0eV energy loss (zero loss peak)	8-8
8.6.2	Range of approx. 10-30eV (plasmon peak)	8-8
8.6.3	Range > 50eV (inner shell losses)	8-9
8.6.4	Background	8-9
8.7	Electron Energy Loss Spectrometer	8-10
8.8	Electron-optical arrangement and operating principle of the OMEGA Imaging Electron Energy Loss Spectrometer	8-11
8.9	Imaging methods	8-14
8.10	Use of the LEO 912 OMEGA for electron-spectroscopic imaging	8-17
8.11	Recording of an EEL spectrum	8-18
8.12	Evaluation of element-spectroscopic images	8-20
8.12.1	Photographic subtraction	8-21
8.12.2	Computer-assisted image evaluation	8-22

8.1 General

Electron Spectroscopic Imaging (ESI) is a new method to improve imaging and analysis in transmission electron microscopy.

An imaging electron energy loss spectrometer is integrated in the electro-optical column of the LEO 912 OMEGA. This **imaging spectrometer** establishes the fundamental difference to conventional transmission electron microscopes (CTEM).

The instrument allows **energy selection** besides angle selection of electrons which the CTEM applies to produce image contrast.

The additional degree of freedom to influence the imaging electrons opens a **new dimension for imaging and analysis by the electron microscope**.

Since the invention of the electron microscope the integration of spectroscopy in electron-microscopic imaging represents the most important step in the development of these instruments. It is comparable with the introduction of filters and spectrometers in light optics.

The spectrometer in the electron microscope improves the contrast when imaging thin and conventionally prepared specimens. Contrast and resolution of thick specimens are improved. Last but not least the depth of focus is optimally maintained.

In thin and unstained specimens, element-spectroscopic imaging supplies exceptionally good element-specific contrast.

An imaging spectrometer offers besides improved imaging new possibilities of preparation, e.g. for labellings in immunology, for the examination of frozen hydrated specimens, and for the analysis of ultramicroscopic structures.

8.2 Elastic and inelastic scattering processes

Electrons may be described either as charged particles (e^-) with the mass (m), or as wave effect with the wavelength (λ). Electrons which are accelerated in an electrostatic field carry the energy to which they were accelerated, e.g. 80 keV, or, correspondingly, the wavelength $\lambda = 0.0042$ nm (Reimer, 1984).

If accelerated electrons impinge on a specimen they cause interactions between the beam electrons and the specimen atoms. These interactions are referred to as scattering. They are the base of image formation and analysis in the electron microscope.

ESI is a method for imaging and analysis based on the utilization of transmitted electrons.

If a specimen is thin, a high quantity of the beam electrons passes through the specimen unscattered because of the loose structure of matter (atomic diameter approx. 10^{-8} cm, atomic core diameter approx. 10^{-12} cm). The scattering probability, characterized by the scattering cross section (σ) is dependent on the atomic number (Z) and the specimen thickness (Carlemalm et al. 1985).

Unscattered electrons do not release measurable energy while transmitting the specimen, and the direction of their flight path remains unchanged. They do not carry specimen information, but essentially define the brightness of the image.

The electrons scattered in the specimen atom are divided into **elastically** and **inelastically scattered electrons**.

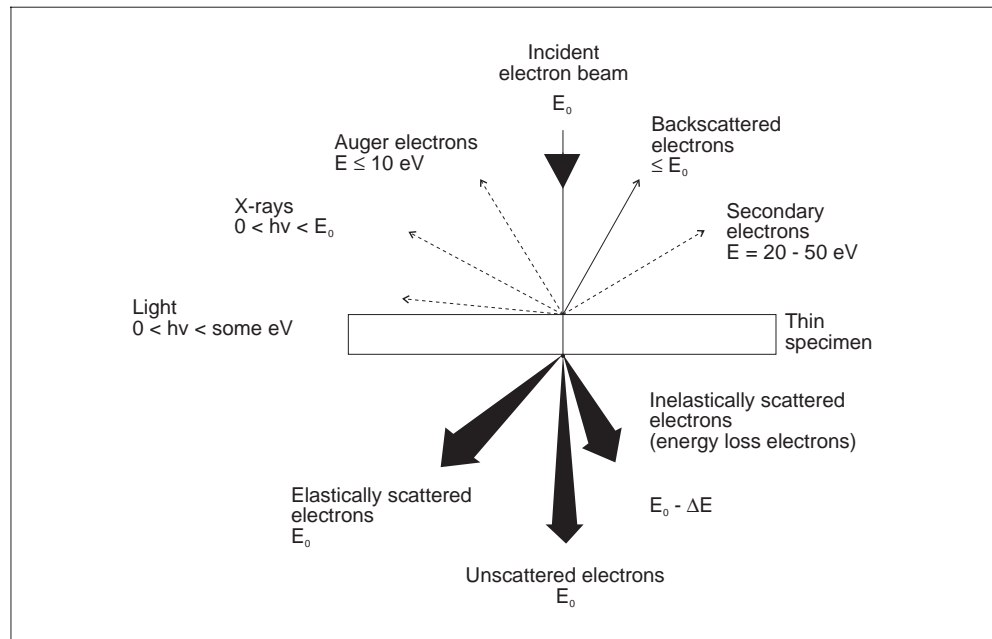


Fig. 8-1: Scattering of electrons

8.3 Elastically scattered electrons

If a beam electron passes through the atomic shell of a specimen atom without hitting a shell electron it is attracted by the positively charged atomic nucleus and deflected. Because of the great differences in the mass of atomic nucleus and electron (atomic nucleus $\geq 1.7 \times 10^{-24}$ g, electron 9×10^{-28} g) the beam electron is elastically scattered. Its flight path is changed, but not the energy.

Elastically scattered electrons remain monoenergetic if the beam electrons are monoenergetic.

The scattering angles in elastic scattering are relatively large; they are in the order of approx. 0-100 mrad. During imaging the objective lens aperture cuts out electrons with large scattering angles. Depending on the aperture diameter it allows only electrons with scattering angles of approx. 6-18 mrad to pass through (angle selection).

The image contrast is produced by cutting out the electrons which are scattered under large angles. The frequency of elastic scattering increases with increasing atomic number. Heavy elements such as uranium (92), lead (82), osmium (76) and tungsten (74) are used for contrast enhancement of electron-microscopic specimens.

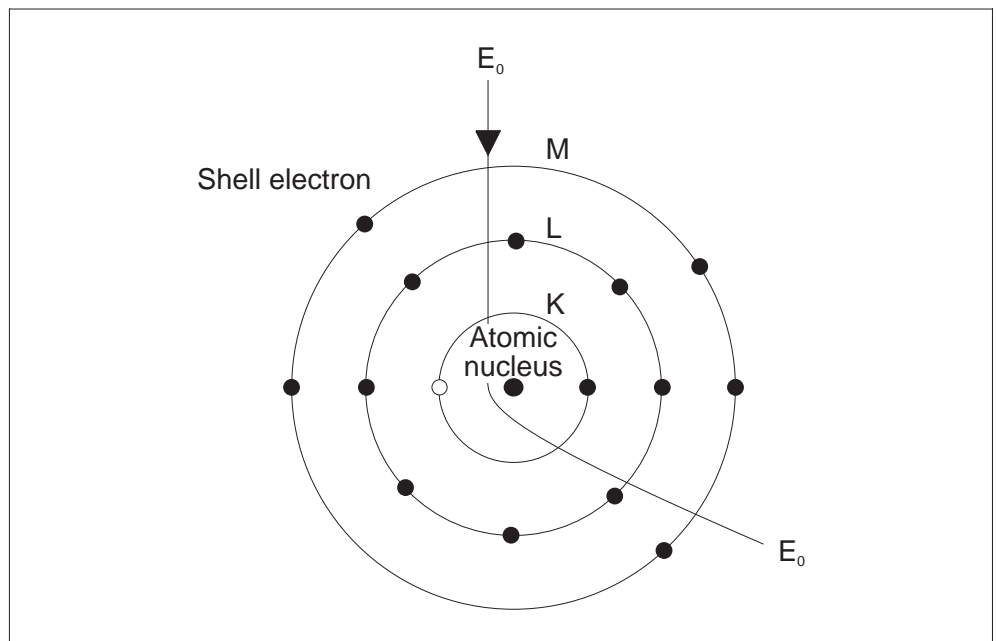


Fig. 8-2: Elastically scattered electrons

8.4 Inelastically scattered electrons

If a beam electron passes through a specimen atom and impinges on a shell electron it causes different interactions.

One is inelastic scattering.

The beam electron is moderated by the inelastic scattering process. During this process it transmits energy to the specimen electron, i.e. releases energy which is measured as energy loss (ΔE).

The most frequent energy losses ΔE are in the order of 10-100 eV.

Inelastically scattered electrons are polyenergetic, or, according to the wave theory, polychromatic. The exact energy distribution is described by the inelastic scattering cross section ($\sigma_{\text{inel.}}$) and displayed by the energy loss spectrum.

The inelastic impact causes besides the energy loss ΔE a slight change in direction, primarily between 0-1mrad. Because of this slight change in direction almost all inelastically scattered electrons pass through the objective lens aperture and reach the image.

Polyenergetic electrons deteriorate the scattering absorption contrast and the phase-contrast conditions. Furthermore, the chromatic aberration of the objective lens with the chromatic aberration constant (C_C) becomes effective in the image.

A special case of inelastic scattering exists if a beam electron transmits so much energy that the shell electron is raised to a higher energy level (excitation) or completely ejected from the atomic shell (ionization).

The energies required for atomic excitation or ionization are characteristic for each single atom and the corresponding shell. If a beam electron ejects a shell electron from the K shell the energy loss is assigned to the atom and the shell, e.g. Mg_K .

The outer shells seen from the atomic nucleus, have several energy levels, for example, the L-shell 3, the M-shell 5, the N-shell 7 and the O-shell 7.

Energy losses which are produced by excitation or ionization of outer shells, are assigned to the atom, the shell and the corresponding energy level, and are designated e.g. Fe_{L1} .

If two energy levels lie closely together and may not be separately resolved, they are combined e.g. to $Fe_{L2,3}$.

The energy loss electrons carry the complete information about the stricken specimen atoms and thus information about the element composition of the specimen.

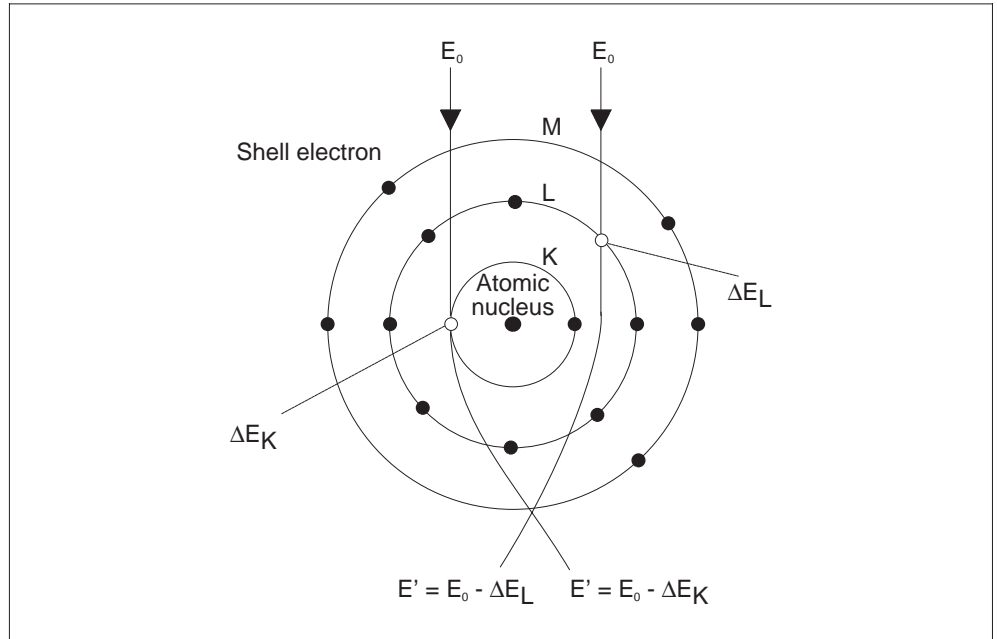


Fig. 8-3: Inelastically scattered electrons

8.5 Multiply scattered electrons

If a beam electron passes through a thin specimen, there is some probability that it is scattered twice or even several times. **The probability of multiple scattering increases with the specimen thickness and increasing atomic number.** The following combinations are possible:

- elastic + elastic
- inelastic + elastic
- multiply inelastic.

Energy is withdrawn from multiply scattered electrons with each inelastic impact. The width of energy distribution and the effect of chromatic aberration of the objective lens increase with increasing specimen thickness.

Multiply scattered electrons change the direction considerably when leaving the specimen, which reduces the percentage of electrons which pass through the objective lens aperture and the intensity of the image.

The **analytical information** of singly and element-specifically scattered electrons is considerably reduced by an increase in multiple scattering.

Multiply scattered electrons do not carry suitable information for energy loss analysis. They increase the background, and the probability of element-specific single scattering decreases with increasing percentage of multiple scattering. This reduces the **signal-to-noise ratio** considerably and thus also the sensitivity of detection.

8.6 The electron energy loss spectrum

The energy loss spectrum (Fig. 8-4) displays the intensity distribution of the imaging electrons as a function of the energy loss. It supplies qualitative and quantitative information about the atomic and molecular structure of thin specimens. The spectrum is divided into the following ranges:

8.6.1 Range around 0 eV energy loss (zero loss peak)

The intensity maximum of the spectrum of a thin specimen lies always at 0eV, because here the highest percentage consists of unscattered electrons and electrons scattered elastically under small angles. The half width of the zero loss peak is a measure of the spectrometer resolution and the energy width of the irradiated electrons.

8.6.2 Range of approx. 10-30 eV (plasmon peak)

The plasmon range comprises approx. 90% of the inelastic scattering processes. It is produced by different, overlapping effects.

Inelastic scattering in crystals is due to the interaction of the beam electrons with the electrons of the lattice system. The lattice system is excited to oscillate by electron bombardment. The electron system oscillates relative to the lattice of the atomic residues. The quantized excitation states of the oscillating electron system are referred to as plasmons. The plasmon range is also the range of collective energy losses of the conduction and valency bands and is of special importance for materials research.

Energy losses of the valency bands inform about molecule bonds. Energy losses of the conduction bands may be used to study dispersion relations in solids, e.g. the determination of the optical constants of solids (refractive index, dielectric constant ϵ).

Different influences limit the use of this spectral range for analysis. These include the overlay with absorption edges of outer shells, radiation damage of molecular units which generate the plasmons and the limited energy resolving power of the spectrometer.

For biological examinations this range is important for images in ratio contrast (Z contrast (Carlemalm et al., 1985)).

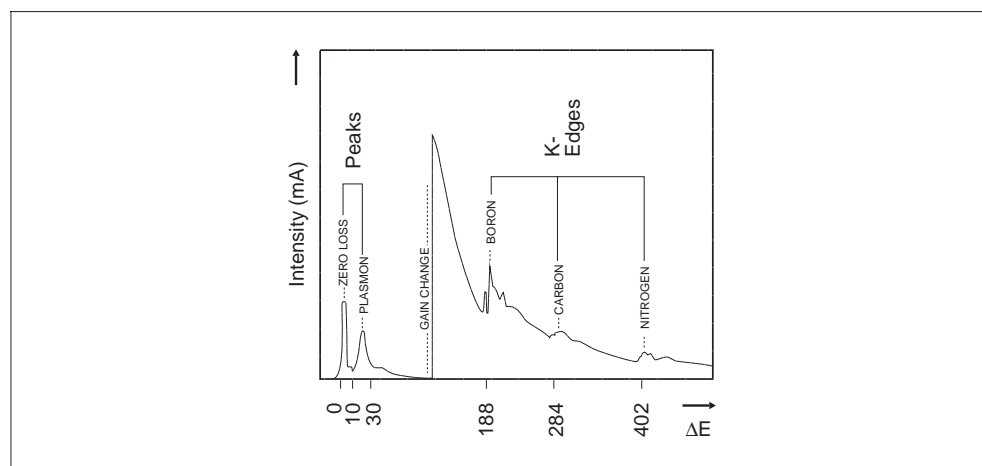


Fig. 8-4: Electron energy loss spectrum

8.6.3 Range > 50 eV (inner shell losses)

This range is the most important to element analysis. It contains all element-specific energy losses generated by excitation or ionization of the specimen atoms. Not only the fixed value of the exciting or ionizing energy may be transmitted to the shell electrons but also kinetic energy of a specific bandwidth.

For this reason, element-specific energy losses do not display sharp peaks in the intensity spectrum. They are characterized by a steep intensity rise which may then drop over several 100eV.

The ranges of element-specific energy losses are referred to as absorption edges. At the beginning after the steep rise they display within the following 300eV energy loss fine structures which inform about the molecular composition of the specimen and the crystallographic structure.

8.6.4 Background

The element-specific absorption edges are overlaid on a background which is produced by non-specific energy losses in the field of the specimen electrons and by multiple scattering. As the background decreases exponentially with increasing energy loss, so that the signal/background ratio changes continuously, it should be considered by calculation for quantitative evaluation.

8.7 Electron Energy Loss Spectrometer

Different spectrometer types are used to spatially separate electrons of different energy, i.e. magnetic prism spectrometers and imaging spectrometers. An imaging spectrometer is integrated in the LEO 912 OMEGA.

Magnetic prism spectrometers are always attachments which are mounted on the electron-optical column below the viewing screen. They consist of a double-focus magnetic prism, the energy-selecting slit and an electron detector to measure the intensity.

Electrons which enter the spectrometer through an entrance aperture are directed on an orbit in the homogeneous magnetic field.

The radii are proportional to the energy of the electrons.

Electrons of equal energy are focused in a point in the energy-dispersive plane. This results in an energy-dependent intensity distribution of the irradiated electrons. If this intensity distribution is shifted across the slit by changing the magnetic field strength of the prism, the electron intensity passing through the slit may be measured by an electron detector and plotted as spectrum vs. energy.

Magnetic prism spectrometers may be used to plot spectra. Imaging is possible only in combination with scanning devices (STEM). Specimens are then scanned line-by-line or point-by-point and the intensities measured with a fixed energy value are displayed as image on a TV monitor. With this method the spatial resolution of the image is limited by the scanning method. The time required to record an image is given by the scanning speed and the number of lines or points to be plotted and is generally very long (R. F. Egerton, 1986). Since 1993 there is also an imaging prism spectrometer which consists of a Schlorfeld spectrometer and complex imaging optics. It is inferior to the integrated omega filter in many points.

Contrary to magnetic prism spectrometers imaging energy spectrometers are not mounted as attachments, but are integrated in the electron-optical system of the TEM. They are also referred to as filters. There are different types of imaging electron energy loss spectrometers, e.g. the prism-mirror-prism spectrometer of the EM 902 A, also known as Castaing/Henry filter, and merely electronmagnetic spectrometers such as omega or alpha filters. The integrated omega filter of the LEO 912 OMEGA has been developed on the basis of calculations by H. Rose (1978) and S. Lanio (1986) in cooperation with D. Krahl (1990).

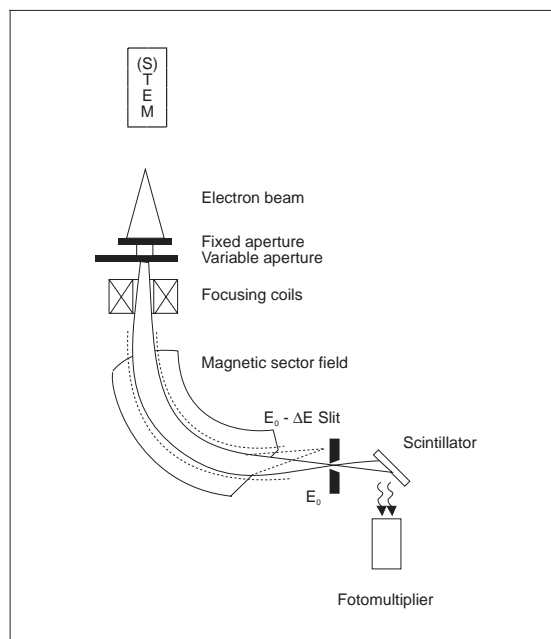


Fig. 8-5: Sectorfield Spektrometer

8.8 Electron-optical arrangement and operating principle of the OMEGA Imaging Electron Energy Loss Spectrometer

The **OMEGA spectrometer** is arranged between two projector lens systems. The first projector lens system varies the magnification and images the rear focal plane of the objective lens (diffraction plane) into the entrance crossover of the spectrometer.

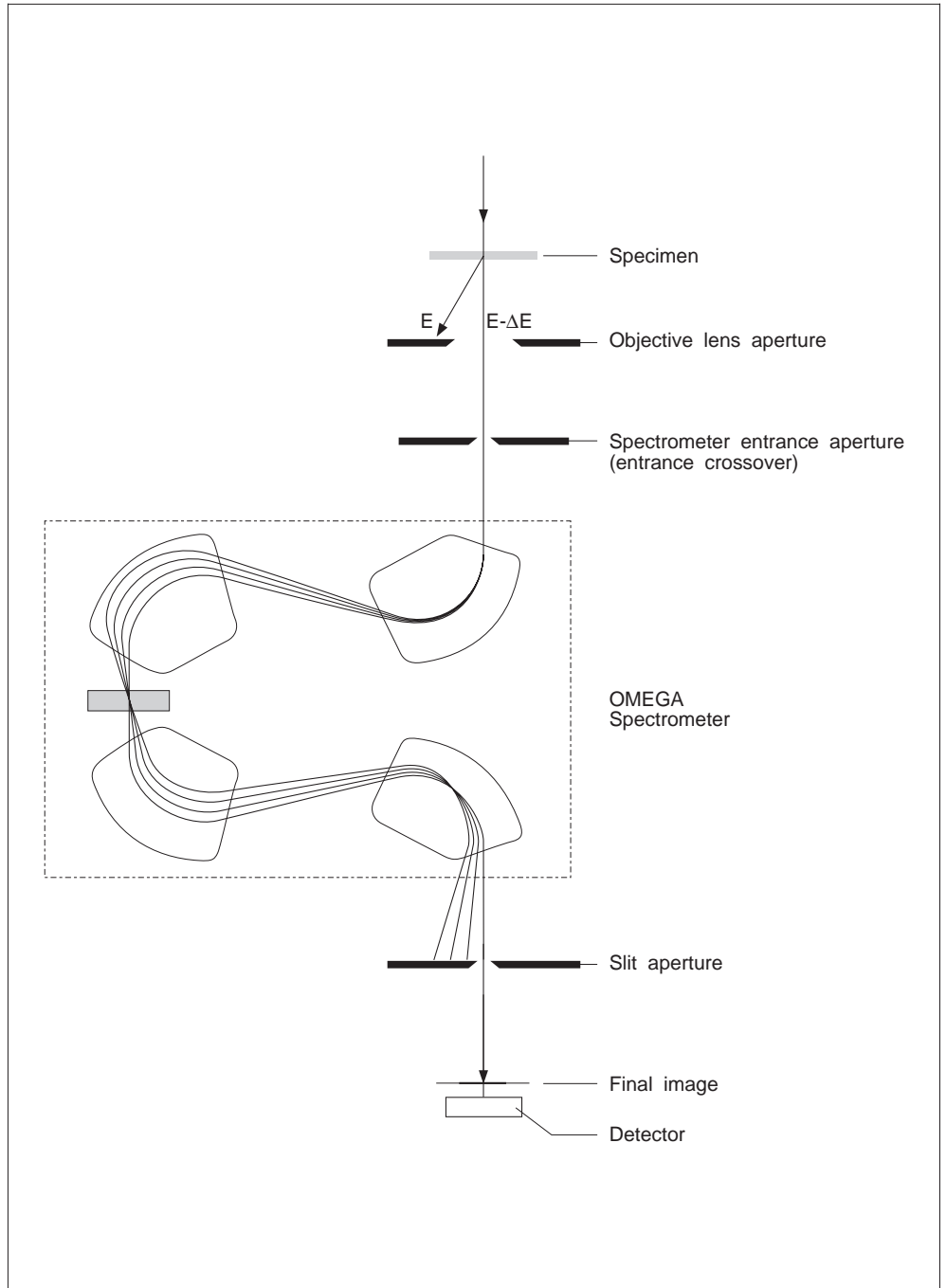


Fig. 8-6: OMEGA imaging electron energy loss spectrometer

In the energy filter of the LEO 912 OMEGA all electrons are spatially separated according to their energy by 4 magnetic prisms which are arranged so that the electron beam path is Ω -shaped. A hexapole/octopole corrector is provided in the spectrometer symmetry plane.

Electrons with unwanted energy are trapped by the slit aperture in the energy-dispersive plane on the optical axis of the microscope.

Elastically or specifically inelastically scattered electrons can be selected for imaging or plotting. The accelerating voltage of the microscope is increased by a corresponding voltage for this purpose, and the linearly resolved energy spectrum is shifted across the slit aperture.

The spectrometer entrance and exit planes are conjugated with the corresponding imaging and diffraction planes, and remain fixed at all magnifications and diffraction lengths.

Electrons which have lost energy in the specimen are more strongly deflected by the magnetic field in proportion to the energy loss, and do not return on the electron-optical axis. They are spatially separated according to their energy losses in the energy-dispersive plane and focused in a band-shaped intensity spectrum. This intensity spectrum contains besides analytical information, the entire image information, because the total rear focal plane of the objective lens, that is the diffraction image, is imaged into the plane of the entrance crossover.

The highest intensity in the intensity spectrum (Fig. 8-7) of a thin specimen lies at an energy loss of 0eV **(a)**. The spectrum image clearly displays the zeroth order and the limitation by the objective lens aperture **(b)**. Above 0eV energy loss the objective lens aperture is blurred to a band because of the continuous intensity curve, and is recognizable only by its outer contours **(c)**.

If the slit selects a spectrum region with a specific bandwidth, the diffraction images of the electrons with the selected energy losses are filtered out as well **(d, e)**. All other diffraction images are cut out and are not imaged.

Not only the spectrum from the energy-dispersive plane can be imaged by the imaging spectrometer: it is possible to switch to the real specimen image in the exit image plane of the spectrometer using the second projector lens stage, like switching between diffraction and imaging in a CTEM. The real diffraction images selected by the slit are then imaged in the final image plane (see also section 1.2.2).

The slit centered to the electron-optical axis defines the energy width of the imaging electrons like an optical filter. The typical energy width of this spectrometer is < 25 eV.

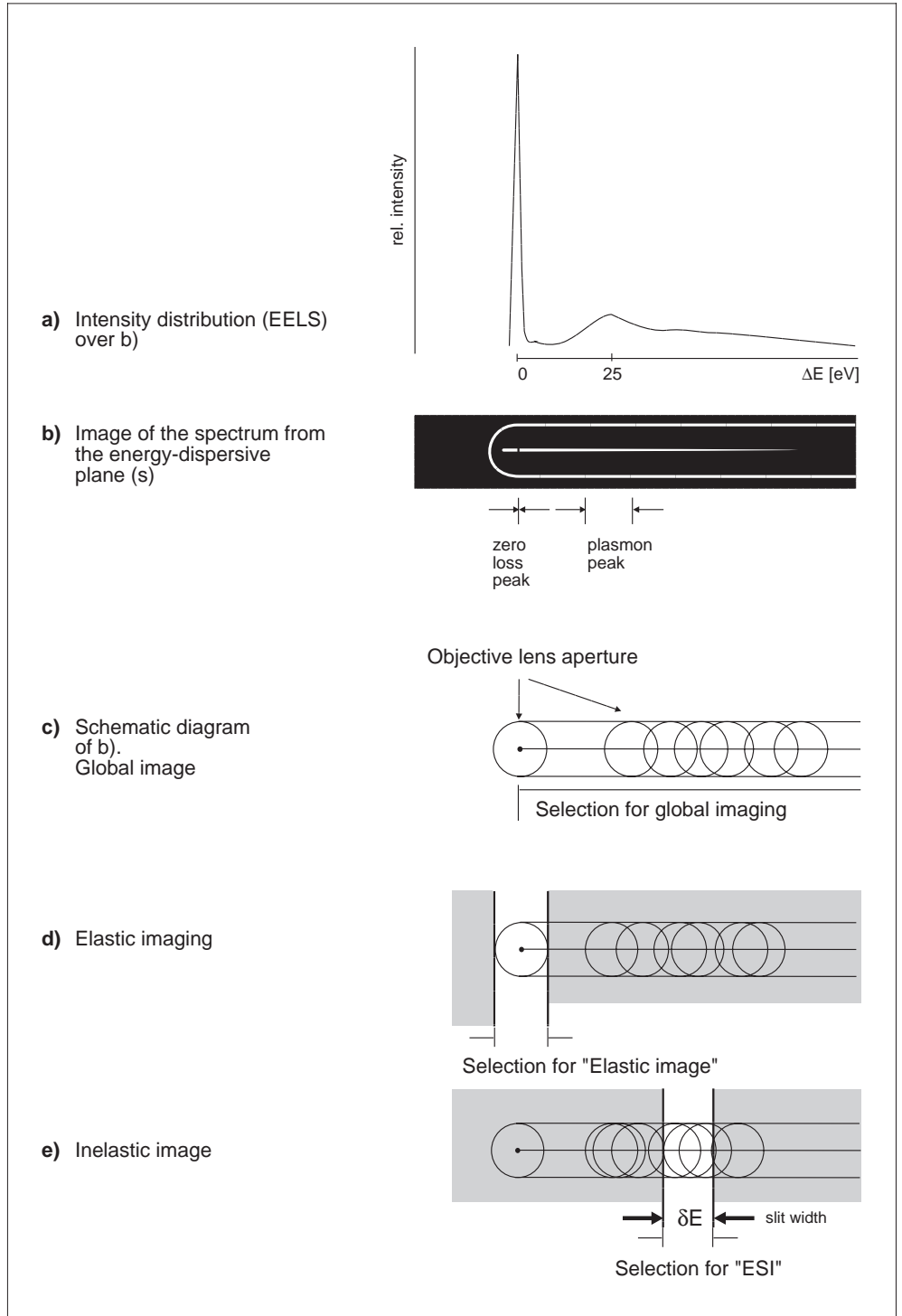


Bild 8-7: Intensity spectrum

8.9 Imaging methods

Its special electron-optical system (4 magnetic prisms) allows the imaging spectrometer not only to transmit the spot image of the electron gun into the energy-dispersive plane, but also to image extended specimen areas with high image quality. Fig. 8-8 shows the functional diagram of the electron-optical system. Different imaging modes can be realized (Fig. 8-7).

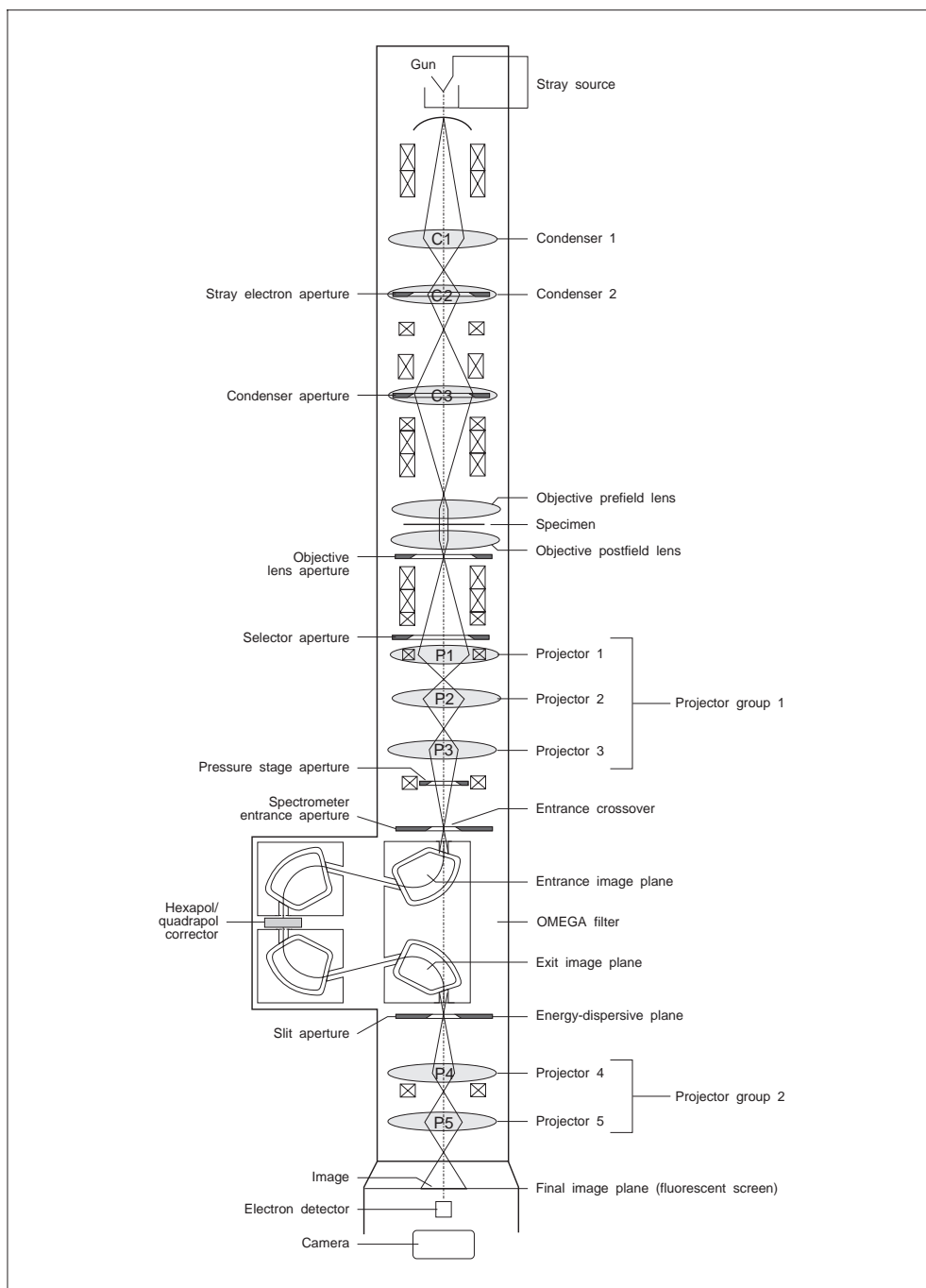


Fig. 8-8: OMEGA-Energiespektrometer, Funktionsschema für Elektronenoptik

Global imaging (diagram c)

If the slit is removed from the beam path or exceptionally wide, the electrons dispersed by the spectrometer according to energy losses are combined by the second projector lens system and projected as "global image" on the viewing fluorescent screen.

Global imaging of thin specimens is comparable with brightfield imaging in the CTEM. The contrast is not improved.

Elastic imaging (diagram d)

In this mode elastically scattered and non-scattered electrons pass through the slit, i.e. monoenergetic electrons with an energy loss of 0eV.

Inelastically scattered electrons are cut out by the slit and are not used for imaging. The imaging mode may be used for brightfield imaging, darkfield imaging and diffraction. The contrast is clearly enhanced in all cases, because the inelastically scattered electrons are cut out.

Electron-spectroscopic imaging (ESI) (diagram e)

Inelastically scattered electrons selected from the spectrum are used for imaging. The accelerating voltage E_0 is increased exactly by the energy loss amount ΔE . If due to inelastic scattering the electrons have lost exactly the energy amount ΔE , they leave the specimen with the energy E_0 and are directed back into the optical axis by multiple deflection in the spectrometer. All other electrons (e.g. those which have lost no energy in the specimen and still hold the energy E_0 and ΔE) are not directed into the optical axis by the spectrometer, but cut out by the slit aperture and are not used for imaging. Thus, specimen and element-specific contrast can be produced.

If two plots were made with energy windows below and directly above an ionization edge of the energy spectrum, there will be a jumping increase in the image intensity of structures which contain higher concentrations of the element that produced the edge; "elemental mapping" is possible by digital subtraction of the two images.

Electron Energy Loss Spectra (EELS) (diagrams a, b)

To plot an energy loss spectrum, the spectrum from the energy-dispersive plane is imaged into the final-image plane. The electron intensity can be measured by an electron detector mounted below the viewing screen and saved in a memory or plotted by an XY printer as a function of the energy loss. The spectrum is shifted across the detector aperture by continuously increasing the high voltage.

Electron-spectroscopic diffraction (ESD)

In this mode the diffraction image (selected-area diffraction) is transmitted into the entrance plane of the energy filter. The diffraction image is then filtered by the energy filter. With this energy filtering the contribution of the individual energy losses to the Bragg reflexes, the Kikuchi bands and the scattering background can be separated.

Advantages of diffraction image filtering:

- Plotting of diffraction images with zero loss electrons ($\Delta E = 0$ eV). This results in background suppression by inelastically scattered electrons and increases the contrast of low-intensity Bragg reflexes. The diffuse diffraction maxima of amorphous objects can be better utilized to determine the atomic density distribution. Diffuse electron-phonon scattering, visible as streaks between the reflexes, can be imaged with better contrast. Inelastic scattering which exists in low-angle diffraction diagrams with great camera lengths at small scattering angles is also suppressed.
- Filtering with energy windows at higher energy losses provides information about the angle distribution of the inelastic scattering processes.
- The Kikuchi bands at higher energy losses provide information about the propagation of Bloch wave fields. The combination of Bragg reflexes at $\Delta E = 0$ eV and a Kikuchi diagram at high energy loss ($\Delta E > 500$ eV) provides for exact orientation.

8.10 Use of the LEO 912 OMEGA for electron-spectroscopic imaging

For ESI the slit aperture is set with the aperture drive and centered, and the energy loss ΔE adjusted by push buttons.

The adjusted energy loss is displayed by the mask on the monitor. The density of the negatives should not be too strong for elemental maps; it should be in the linear range of the characteristic curve of the film material. Two data records are available for the density adjustment of the automatic exposure system.

Exposure series with different energy loss settings can be adjusted and recorded manually, or automatically using the option EXPOSURE SERIES.

The exposure time increases with increasing energy losses, and may be 50 s or more.

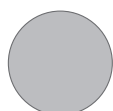
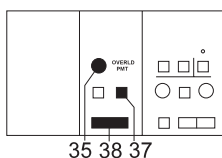
High-speed film material, e.g. Kodak SO 163, should, therefore, be used for ESI exposures.

8.11

Recording of an EEL spectrum

Photography (without electron detector)

- The EEL spectrum is displayed on the fluorescent screen in SPECTRUM mode. The slit aperture is pulled back.
- The spectrum can be focused with knob (35) and shifted to the interesting energy range with double key ENERGY LOSS (38) (ΔE setting).



ENERGY LOSS

- This allows photography of partial ranges of the energy loss spectrum of approx. 120 eV.
- After development of the film the spectra are evaluated with a densitometer.

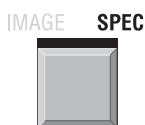
Electron detector

The electron detector (accessory) is mounted below the viewing fluorescent screen (this screen has a hole in the center). It measures the electron intensity of the final image. The spectrum may be plotted by an XY recorder or saved by a computer system.

There are different methods to plot the EEL spectrum of a selected object area:

SPECTRUM mode

- Set selector key IMAGE/SPEC (37) to SPEC.



ENERGY LOSS

The spectrum of a selected object area is displayed on the fluorescent screen. Changing the ΔE value with double key ENERGY LOSS (38) shifts the spectrum across the detector aperture. Recording the measured electron intensity as a function of the calibrated energy loss ΔE yields the spectrum.

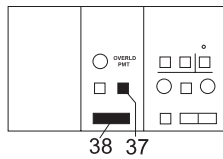


IMAGE SPEC



ENERGY LOSS

IMAGE mode

- Set selector key IMAGE/SPEC (37) to IMAGE.

The specimen area selected for analysis is adjusted with the specimen shift so that the feature to be measured lies in the detector aperture on the fluorescent screen. Changing the ΔE value with double key ENERGY LOSS (38) changes the image intensity analogous to the spectrum. The spectrum of this specimen area is also recorded by measuring the intensity as a function of the energy loss ΔE . The size of the specimen area selected for analysis is adjustable by the magnification (M). The diameter of the area results from

$$\text{Analysis diameter} = \frac{1}{M} * \varnothing \text{ detector aperture}$$

For $M = 250,000x$ and 3mm detector aperture this yields an area for analysis of 12nm.

8.12 Evaluation of element-spectroscopic images

A matching image pair recorded with energy losses below and above the element-specific absorption edge is required for a high-resolution elemental map.

The elemental map is produced by subtraction of the two images. This is necessary because the absorption edges are always overlaid by a background. The image pair therefore consists of the element-spectroscopic image (for phosphorus e.g. $\Delta E = 150$ eV) and the reference image (for phosphorus e.g. $\Delta E = 110$ eV).

Subtracting the reference image from the element-spectroscopic image yields a difference image which is referred to as net elemental map.

Element Z Symbol	Absorption edge (eV)	ESI reference ΔE (eV)	ESI ΔE (eV)
6 C	284 K	270	300
7 N	402 K	380	430
8 O	532 K	510	550
9 F	685 K	660	710
11 Na	1072 K	1050	1090
12 Mg	1305 K	1290	1330
13 Al	1560 K	1530	1590
14 Si	1839 K	1810	1870
15 P	132 L 2,3	110	150
16 S	165 L 2,3	150	180
17 Cl	200 L 2,3	180	220
19 K (*)	294 L 2,3	280	310
20 Ca	346 L 2,3	320	360
26 Fe	708 L 2,3	690	716
29 Cu	931 L 2,3	900	960
(*) The detection of potassium (K) is critical with high carbon (C) concentration because of overlays of the absorption edge around 300eV.			

Energy losses $\Delta 20E$ for biologically relevant elements.

**SPECIAL NOTE:**

At least two background images are required for quantifiable elemental maps and if the background curve in the spectrum drops considerably.

The correct background image in front of the element absorption edge is then obtainable through pixel-by-pixel extrapolation (so-called 3-window method).

One handbook "EEL Spectroscopy" is supplied with each LEO 912 OMEGA. It contains tables and spectra of all elements and a comprehensive introduction to the method.

8.12.1 Photographic subtraction

There is a simple but time-consuming method for the subtraction of images, with only little technical requirements. A normal enlarger as used in any photographic laboratory is sufficient. The image pair, available in the form of two negatives, is evaluated as follows:

Make at first from the negative of the reference image several contact prints of medium but slightly different density on a linear negative film, that is a positive print of the reference image.

Place one of the transparent positive reference images on the negative of the elemental spectroscopic image. If both images exactly correlate, all structures of the background will disappear in a medium gray. If this is not the case, select another positive reference image of suitable density from the density series.

The optimized negative pair will display the net element distribution dark on gray background. Further photographic processing, e.g. low-power or sectional enlargements, will produce high-resolution elemental maps of extended specimen areas. Areas with high element concentration are displayed with great brightness.

For the detection of several elements in one and the same specimen area, the above-mentioned exposure and image processing method should be applied for each element.

**SPECIAL NOTE:**

Only **qualitative** but no quantitative elemental maps may be produced using the method of photographic subtraction. Mass effects are not considered.

8.12.2 Computer-assisted image evaluation

An image analysis computer is available for the LEO 912 OMEGA, which is specifically tailored to the applications of the instrument.

The system evaluates images which are recorded online into the video memory from the image intensifier camera and digitized.

In the same way SSCCD cameras can be adapted for image recording and evaluation.

Various programs are available for **qualitative and quantitative** evaluation of ESI images, and for the evaluation of EELS spectra.

For details see the separate operating instructions.

9

**unassigned at the present
time**

10

Installation Guide

Table of contents

10	Installation Guide	
10.1	Before installation	10-3
	Unloading	10-3
	Storage	10-3
	Unpacking	10-3
	Means of conveyance	10-3
10.2	Installation place requirements	10-4
	General requirements	10-4
	Ceiling height	10-4
	Dimensions of doors on transport passages	10-4
	Installation area	10-5
	Room illumination	10-6
	Room climate	10-6
	Magnetic strayfields	10-6
	Mechanical vibration	10-7
	Ground load	10-8
	Supply and disposal	10-8
	Electrical supply	10-8
	Compressed-air supply	10-9
	Nitrogen supply	10-9
	Waste-gas line	10-9
	Water cooling	10-10

10.1 Before installation

Unloading

The LEO 912 OMEGA should be unloaded and transported only on a flat floor, and the containers should not be knocked.

Storage

The packaged LEO 912 OMEGA transport units should be stored in a roofed-in storage facility close to the place of installation.

Permissible storage temperature: between -10°C and +50°C

The storage temperature should never drop to less than -10°C.

Unpacking

The components of the LEO 912 OMEGA may be unpacked only by our specialists. Provision should be made for storing the empty crates.

Means of conveyance

Suitable conveyance (e.g. lifting truck) should be made available for moving the microscope to the unpacking and installation place. Dimension and weight of the LEO 912 OMEGA components and transport containers are listed in the table below.

No.	Transport container for	Drawing No. of transport container	Dimensions in mm (max)			m ³	Tare kg	Gross max. kg
			L	W	H			
1	LEO 912 OMEGA outer Base container instrument	349156-9006.000	2356	1066	2506	6.24	345	approx. 1 350
2	High-volt. unit outer container inner container	349156-9004.000	898 742	904 748	1608 1364	1.31 0.76	90 80	approx. 320
3	Power supply	349156-9003.000	945	764	1560	1.13	100	approx. 255
4	Table tops and sheathing	349156-9005.000	1347	826	888	0.99	95 150	
5	Assembly kit EDX Cooling	in pos. 4 original packing original packing						

Table 10-1: Dimensions and weight

10.2 Installation place requirements

General requirements

The workroom should be a clean, dry laboratory room.

Ceiling height

The overall height of the LEO 912 OMEGA of 2.33m requires the following individual heights:

- With supplied crane
Minimum ceiling height: 2.80m
The swivel range of the crane is approx. 1m.

- With a crane rigidly mounted on the ceiling
Minimum headroom beneath the pulley: 2.45m
- With completely pulled-up hook
Minimum length of running rails: 1.50m

Dimensions of doors on transport passages

for the unpackaged instrument on conveyance

Minimum height: 2.05m

Minimum width: 0.8m provided there is sufficient space in front of the door
(e.g. corridor width approx. 1.8m)

Installation area

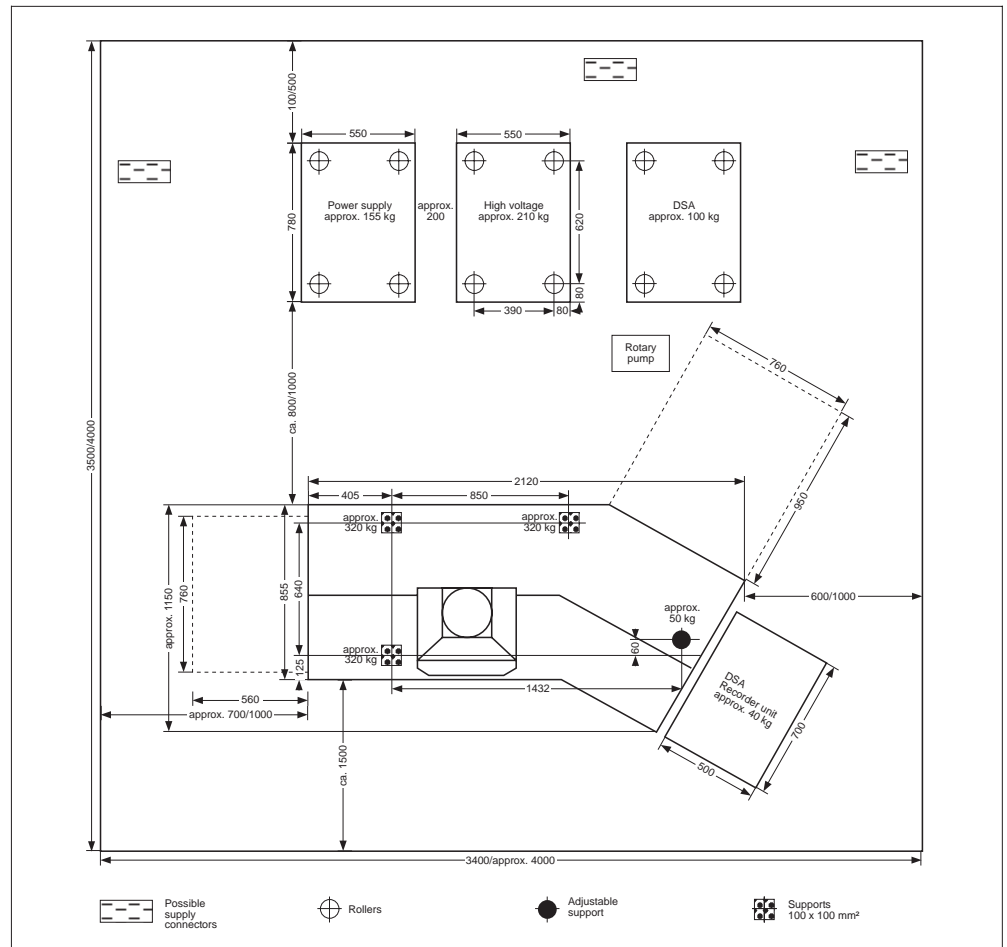


Fig. 10-1: Installation example



Double dimensions mean: MINIMUM / OPTIMUM dimension for servicing.

The microscope must be easily accessible *from all sides* (servicing!).

Minimum distances (see Fig. 10-1):

Wall to back of LEO 912 OMEGA: 1.70m (optimum: 2.00m)

Wall to left of LEO 912 OMEGA: 0.7m (optimum: 1.0m)

NB:

Movement of the electronic cabinets is limited by the cable length especially of the high-voltage unit.

Room illumination

It should be possible to dim the room illumination, preferably by a dimmer mounted on the LEO 912 OMEGA and provided with an ON/OFF switch. Bright room illumination should be available for preparatory work and servicing. Ruby light should be provided for film exchange.

Room climate

Permissible environmental temperature:	between + 15 °C and +30 °C
Permissible temperature fluctuation:	max. 3 °C/hr
Permissible relative humidity, not condensing:	70%

Higher humidity or temperature requires air conditioning which provides for obtaining the above mentioned values.

NB:

The air condition should not cause air flow around the column of the LEO 912 OMEGA.

Magnetic strayfields

To obtain the guaranteed resolution of the LEO 912 OMEGA the magnetic strayfield over the entire frequency range should not exceed the value

$$0.4 \mu\text{T} = 4 \text{ mG (peak to peak)}$$

It is particularly important that this limit is observed in the objective lens and projector lens area, that is between 1.40 m and 1.80 m above ground.

Mechanical vibration

The permissible ground vibrations at the place of installation are shown by the diagram in Fig. 10-2. The vibration conditions can be reliably determined only by measurement. The measurement can be made

- by the customer
- by an authorized institute
- by the Zeiss technical service.

Before the LEO 912 OMEGA is installed, the measuring results should be available for examination.

NB:

The air condition should not generate appreciable sound in the frequency range between 10 and 20Hz.

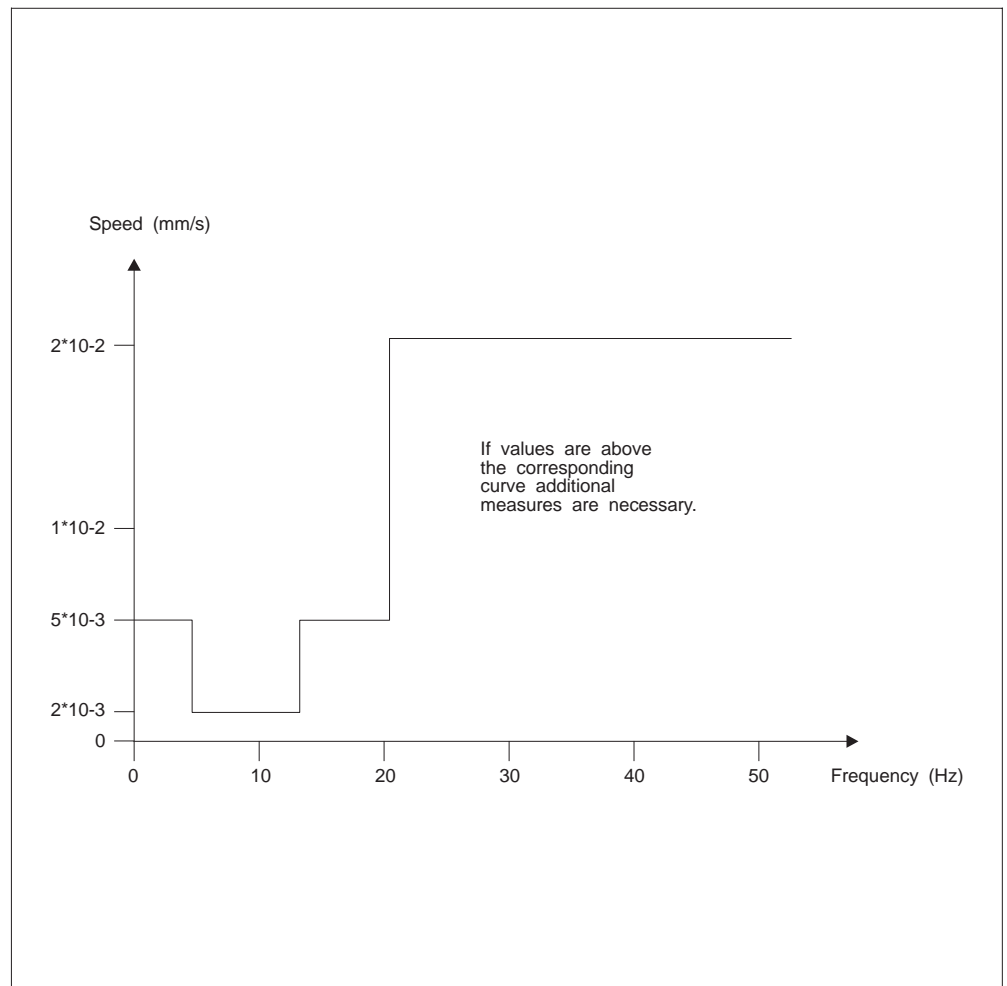


Fig. 10-2: Permissible ground vibration

Ground load

The permissible ground load is shown in Fig. 10-1.

If necessary, reinforcement of ground or basement should be made upon agreement with an engineer.

Supply and disposal

Fig. 10-1 shows where the supply and disposal outlets of the LEO 912 OMEGA should best be provided.

Electrical supply

General

- The LEO 912 OMEGA is provided for connection to 3-phase supply so that the apparent power consumption of max. 7kVA is distributed to 3 phases. However the instrument does not necessarily *need* a 3-phase supply (e.g. rotary-field motors) so that 2 or 1-phase operation is also possible. Special attention must then be paid to the maximum current load.
- To obtain satisfactory stability of the power supply it is generally sufficient to connect the LEO 912 OMEGA directly to the main distributor. In case of short-term voltage fluctuations which exceed the tolerance range a line analysis should be made.
- A second 4mm earth connector can be connected, if necessary.
- The LEO 912 OMEGA is connected to the line by CEE plug or fixed connector.

Elimination of disturbing influences

The instrument should be connected to a circuit which does not supply surge load or high-consumption equipment (e.g. elevators, air condition, welding plants). It should not be installed close to plants emitting high frequencies (e.g. electrical discharge plants).

Power supply data

German standard	: 230/400 V, 3 phases
US standard	: 3-phase current
perm. voltage fluctuation (Germany)	: +10%/-15%
perm. voltage fluctuation (USA)	: (5%
Operating frequency	: 50/60Hz
perm. frequency fluctuation	: 47 - 63Hz
Line breakdown	: max. 20ms (1 period) at 50Hz)
Fuse protection for each 220V-/240-V phase	: 25A (optimum: 32A)
Heat emission into ambient air:	: 2-4kW
Apparent power consumption	: max. 7kVA

Laying the connecting cables

A cable duct with T-piece is supplied to protect the cables.

Dimensions: 61x110mm, 2x2000mm long, 1 T-piece

The cable duct is mounted on the ground and is sufficiently large to accommodate all cables. An existing cable duct or cable chamber in the floor may also be used.

Compressed-air supply

Compressed air is required to operate the valves.

- Air pressure
min. 6bar, max. 7bar
A pressure regulator is built into the LEO 912 OMEGA.
- Air purity
Purified, purity 97%
The air should not contain solid bodies and gaseous oil and water residues. The integral submicrofilter should be supplemented by a charcoal filter, if necessary.
- Air consumption between 10 and 15l/min
If the compressed air is supplied by a compressor the final pressure should be 6bar.
Tank capacity approx. 50l (because of frequent start-up).
The compressor must be equipped with an air filter and a water shedder. The filter must be regularly controlled and the shedder emptied.
Operation using compressed-air bottles (50l, 200bar) is permissible only for a short time (approx. 10-20hrs).
- For the positions of outlets see Fig. 10-4. The fitting must be suitable for connection of a PU hose with 4mm inside diameter (supplied). The hose installed must be protected.

Nitrogen supply

Nitrogen is required to ventilate specimen and filament chambers as well as the camera chamber.

- Connection by pressure reducer, primary 200bar, secondary 0.1 to 0.3bar with display, PU 4 hose (4mm inside, 6mm outside diameter)
- Quality 4.6: nitrogen content > 99.996vol%, water content \leq 5vpm

Waste-gas line

A waste-gas line is required for the rotary pump.

A hose fitting for 8mm inside diameter should be provided. The waste-gas line is led out of EM room over an oil-mist filter (option).

Water cooling

Water cooling should be provided for the lenses and power supplies; it should not be installed in the instrument room.

Specifications:

- Water pressure: 4 to 5bar, cooling brine max. 20%
- Water pressure: 3bar, pure water
- Water pressure fluctuation: ≤ 0.1 bar
- Supply temperature: approx. 18 °C, min. 10 °C
- Temperature stability: 1 °C /hour
- Consumption: approx. 2l/min
- Cooling capacity: 2kW
- Fitting: R3/8 male.

NB:

Install the valve at least 75mm between wall and thread.

The supplied hoses are connected during installation and should be protected.

Recommended cooling:

Closed-loop cooling CZ 2551 A (air) or W (water) by Colora. Power requirements: 230/400V, 50Hz, 3 phases. The system should not be connected at the place of installation of the LEO 912 OMEGA.

Connection to the house water supply requires a filter and, possibly, a pressure reducer.



Technical Data

Table of contents

11	Technical Data	
11.1	Gun	11-3
11.2	Illumination system	11-3
11.3	Objective lens	11-5
11.4	Specimen plane	11-6
11.5	Imaging system	11-7
11.6	Shutter housing and Viewing head	11-9
11.7	Instrument control and operation	11-10
11.8	Vacuum system	11-12
11.9	Camera system	11-13

11.1

Gun

Accelerating voltage

- 60, 80, 100, 120kV
- variable in steps of 10V to 1000x (**option**)
- Energy loss adjustment variable in steps of 0.2 V (max. 2.5 kV)

Separate microprocessor control unit with parallel, bidirectional data link to host computer

Tungsten or LaB₆ filament (**option**), programmable heat-up and cool-down time with overheat protection

Pneumatic gun lifter

Filament hour counter

11.2

Illumination system

Highly flexible Köhler illumination system with 4 lenses:

- Condensers 1 to 3
- Objective lens condenser C-O
C-O prefield coefficients: $C_s = 2.7\text{mm}$, $C_c = 2.7\text{mm}$

Automatic (AIS) and Manual Illumination-aperture Selection (MIS) as a function of the magnification, for optimum specimen protection and homogeneous illumination of the imaged specimen area alone

AIS = **A**utomatic **I**llumination-aperture **S**election, Zeiss patent or

MIS = **M**anual **I**llumination **S**election

Push-button operated change between parallel widefield (TEM) and spot (SPOT) illumination or nanoprobe, without manual aperture change, separate storage of electron-optical data files

Constant brightness automatically maintained (CONSTANT BRIGHTNESS)

Probe size

- Area illumination (TEM) 1 μm to 75 μm (illuminating aperture 0.02 to 5 mrad)
- Spot illumination (SPOT) 1.6 nm to 5 μm

Permanent display of probe size or illuminating aperture on the monitor.

Darkfield illumination (DARKFIELD) with variable offset (5 separate memories) in cartesian or polar coordinates ($\pm 5^\circ$)

Hollow cone illumination (CONE ILLUMINATION)

Independent illumination tilt (TILT) and shift (SHIFT) with deflecting systems symmetrically positioned to the specimen. No compensation required in SPOT or TEM illumination mode.

Beam deflection (shift)

- $\pm 100 \mu\text{m}$ at 3,150x to 500,000x (MAG mode)
- $\pm 1\text{mm}$ at 80x to 2,000x (LM mode)

Beam deflection for Minimum Dose Focusing (MDF) (**option**): $\pm 25 \mu\text{mR}$ maintains parallel illumination or selected convergence angle

Condenser zoom with 26 steps. Separate adjustments for MAG / LOW MAG and SPOT / TEM illumination

Condenser aperture with metal bellows and click-stop mechanism

Aperture size:

- one 5-hole aperture (37.5, 75, 150, 300, 600 μm , automatic, computer-controlled setting)
- one 1-hole aperture 20 μm
- one 1-hole aperture 400 μm
- **optional** instead of the above 1-hole apertures:
 - Cap (EDX) aperture
 - 5 μm for small SA areas or SPOT SCAN methods

Condenser apertures may be used as selector apertures (Selected-Area (SA)) apertures. Illuminated and diffracting specimen areas are defined simultaneously.

11.3 Objective lens

True symmetrical, analytical objective lens of the C-O type for both widefield (TEM) and spot (SPOT) illumination

All operating modes (analysis, imaging, diffraction, CBED and probe) are carried out at constant objective lens excitation and assigned to the eucentric (symmetrical) specimen plane.

Characteristic features:

$f = 3.6\text{mm}$, $C_s = 2.7\text{mm}$, $C_c = 2.7\text{mm}$, current stability better than $2\ \mu\text{A}$

Objective lens (technical data) Resolution (TEM)

- elastic imaging: point 0.37 nm
line 0.2 nm
- inelastic imaging
($\delta E = 10\ \text{eV}$): 0.8 nm

Calibrating function:

sets the objective lens to calculated optimized value, imaging with spot illumination and eucentric reproducibility

Focusing modes

- Zoom focus (continuous, magnification-adapted step size)
- Selectable step size (4 nm to 124 nm, independent of the magnification)
- Constant focus in the magnification ranges 3,150x to 250,000x and 315,000x to 500,000x

Automatic defocusing modes

- optimized, magnification-dependent underfocus (low, medium, high)
- high-voltage-compensated defocus (Scherzer defocus)
- fixed defocus (selectable from 4 nm to 64 μm)
- automatic through-focus series (**option**)

Objective lens aperture diaphragm

- over the entire magnification range in MAG mode (3,150x to 500,000x) provided in the rear focal plane of the objective lens
- Metal bellows and click-stop mechanism
- three 1-hole apertures: 90 μm , 60 μm , 30 μm

11.4 Specimen plane

Specimen stage

- Eucentric *side-entry goniometer* ($\pm 60^\circ$, LEO patent)
- X, Y, Z and Θ (tilt) axis and additional tilt axis Φ (**option**) or axis of rotation ε (**option**)
All axes motorized and digitally controlled with parallel, bidirectional data link to the host computer
- Display, storage and relocation of all 4 or 5 (**option**) axes, up to 99 positions storable
- Trackball for X and Y fine positioning. Speed adjusted to the magnification. Minimum step width 4nm at magnifications as from 100,000x.
- Pushbuttons or footswitch (**option**) for the tilt axis, variable tilting speed
- Pushbuttons for X and Y coarse positioning
- Specimen shift:
 - X axis 8.5 mm (4 mm motorized)
 - Y axis 2 mm
 - Z axis ± 0.4 mm at 60° tilt angle
- Help function for eucentric positioning including objective lens calibration
- Automatic functions (**options**):
 - meander scanning of a definable specimen area at variable speed and overlap
 - photomontage with variable image size and overlap
 - tilt series
- Accuracy of position display $1\mu\text{m}$
- Relocation accuracy (4 axes):
 - using reference point $0.2\mu\text{m}$
 - without reference point $2.0\mu\text{m}$

Specimen holder

- Standard specimen holder for 2 specimens, 3mm diameter
- Low-background holder (EDX) for 2 specimens ($\pm 60^\circ$, **option**)
- Double tilt holder (**option**)
 1. Tilt angle $\Theta = \pm 60^\circ$
 2. Tilt angle $\Phi = \pm 30^\circ$,
All axes motorized and digitally controlled, variable tilting speed
- Rotary holder (**option**)
 - Angle of rotation $\varepsilon = 360^\circ$, continuous
 - All axes motorized and digitally controlled, variable speed of rotation
- other specimen holders on request

11.5 Imaging system

Magnification zoom with 7 imaging systems:

Objective lens and projector lenses 1 to 5 and OMEGA spectrometer

Lens current stability better than 10 μ A

Magnification

- Range (LOW MAG + MAG): 80x to 500,000x in 38 steps
- Selected area range: 3,150x to 250,000x in 20 steps
- LOW MAG range: 80x to 2,000x in 15 steps
- Spectrum imaging: 40x to 315x in 10 steps

Camera lengths

- Selected-area diffraction: 290 to 7200mm in 15 steps
- Small-angle diffraction: 10 to 800m in 23 steps

Lens programs

- Optimized distortion (for every high voltage)
- free lens program for user definition (**option**)

Electromagnetic image shift system

- Constant shift independent of imaging mode or magnification
- Maximum image shift ± 50 mm on viewing screen
- Separately stored values for selected-area magnification or diffraction and LOW MAG / small-angle diffraction and spectrum

Stigmators

- Separately stored values for selected-area magnification or diffraction and LOW MAG / Small-angle diffraction

Selector or intermediate image aperture

for optimized contrast at low magnifications (LOW MAG) (LEO patent)
or as additional selected-area aperture

- Metal bellows and click-stop mechanism
- three 1-hole apertures of 200, 100 and 50 μ m
- Aperture in focus throughout the entire magnification range

Spectrometer

- Ω type with 4 sector magnets and one corrector element in the symmetry plane
- Energy loss range: 0 to 2500 eV
- Energy resolution: image (full format, 100mm diameter): 10 eV
Spectrum or reduced image format
(20 mm diameter): 1.5 eV
- Dispersion at 120 kV: energy-dispersive plane: 1.0 $\mu\text{m}/\text{eV}$
Final image plane (variable): 0.3 mm/eV to 40 $\mu\text{m}/\text{eV}$
- Spectrometer entrance aperture with metal bellows and click-stop mechanism
(100 μm , 800 μm)
- Slit aperture to select the energy window in the energy dispersive plane with
metal bellows and click-stop mechanism (variable from 0 to 100 μm)

11.6 Shutter housing and Viewing chamber

Vibration-insulated mechanical shutter

Central beam stop above 35mm camera

Two large ports for accessories (TV and 35mm camera can be used simultaneously).
Image in focus on the TV monitor and on the viewing screen.

Viewing window 220 mm x 127 mm

Binocular viewing microscope with 9x magnification, shiftable (35 mm in X direction

Fluorescent screens

- Large fluorescent screen, 145 mm dia.
- Small focusing fluorescent screen, 70x20 mm
- Automatically or manually operated, pneumatic lifter

11.7 Instrument control and operation

Expert operating system

Host computer with AT-compatible architecture and multitasking system

- 30MB hard disk
- 3.5" / 1.44MB floppy disk drive
- 2 internal and 3 external RS 232 interfaces **(option)**
- 4 internal and 2 external parallel interfaces **(option)**
- ASCII keyboard

Dedicated autonomous subsystems for

- Vacuum system
- Goniometer
- Camera
- High voltage

Subsystems individually programmed and failsafe (EPROM). Immediate response by each individual system to operating or system commands.

Multilayer management system

- Interrupt-driven, bidirectional communication between host computer and subsystems by parallel data lines
- Direct control of lens and deflecting systems through multiplex control system
- Full remote-control capability through 2 RS 232 and 1 TTL interfaces **(option)**

User interface

Menu-oriented system operation by a monitor (Electro Luminescent Display (ELD)) and 16 softkeys

Complete data record storage on hard disk and floppy disks

Automated operating modes and functions:

- AIS (**A**utomatic **I**llumination **S**election) for magnification-dependent, automatic adaptation of the illuminated specimen area to the imaged specimen area
- MIS (**M**anual **I**llumination **S**election)
- Cone illumination (CONE ILLUMINATION)
- Coarse/fine and continuous focusing
- Lens programs (distortion-optimized)
- Goniometer and camera exposure series: meander scan and photomontage, tilt, focus and exposure time series **(options)**
- Minimum Dose Focusing (MDF) **(option)**
- Calibration of magnification display and printout **(option)**
- FREE LENS CONTROL **(option)**
- Remote control (REMOTE mode by 2 RS 232 and 1 TTL interfaces) **(options)**
- Spectrometer/high voltage
- Darkfield imaging, offset in cartesian and polar coordinate definition
- Controlled filament heating

- Save, recall and reset of user parameters for
 - Gun alignment
 - Goniometer
 - Camera
 - Darkfield
 - AIS
 - MDF
 - δE
- Calibrating functions for
 - Image shift
 - Beam deflection
 - Focus (optimized objective lens current)
 - Magnification
 - Image stigmators
 - Illumination stigmators
 - AIS
 - δE
- Extensive adjustment help program ADJUST ASSISTANCE
- High-voltage wobbler
- Focus wobbler
- Focusing aid
- Alignment aid for eucentric specimen plane (goniometer tilt axis wobbler)
- Camera ventilation
- Column ventilation

Beam deflecting system above the specimen

Simple and reproducible handling of beam tilt and beam shift because of symmetrical design of deflecting system around the C-O lens and therefore around the specimen

Ergonomically organized keys and encoders for most common functions in addition to monitor and function keys

Personalized storage of system parameters on hard disk or floppy for multi-user environments

Extensive help explanations of all functions to be called up by function keys

Self diagnosis function:

Unpermissible operating statuses are recognized and displayed on the monitor, the instrument is automatically turned off. In addition they are documented in a history file on the hard disk. All operating statuses of the vacuum system are displayed by an LCD independent of the monitor.

Diagnosis for:

- the entire vacuum system with more than 30 different messages (pre-vacuum pump, turbomolecular pump, ion getter pump, measuring tubes, valves)
- cooling water flow
- gun
- goniometer
- camera
- the entire digital system.

The *expert operating system* also checks remote control commands for correctness

11.8 Vacuum system

Dry and fast turbomolecular / ion getter vacuum system with ion, Penning and Pirani measuring systems (final vacuum at least 5×10^{-7} hPa)

- Ion getter pump ($0.12 \text{ m}^3/\text{s}$) for specimen and filament chambers
- Turbomolecular pump ($0.19 \text{ m}^3/\text{sec}$) for viewing head, camera chamber and spectrometer area, and to prepump the column
- Two-stage rotary pump ($8 \text{ m}^3/\text{hr}$) for the prevacuum
- Adsorption trap with regeneration program for the rotary pump (**option**)

Pumpdown time after switch-on max. 5min

Fully automatic separate microprocessor control unit with parallel bidirectional data link to host computer

Differentially pumped vacuum with vacuum and cleaning tubes

Automatic valve for the differential pump system

Metal bellows for all aperture feed-throughs

Anticontaminator, surface $> 100 \text{ cm}^2$, cooled down to less than 100K

Vacuum menu and operating controls on the monitor and separate vacuum display and operating keys independent of host computer

Energy-saving operating mode

11.9 Camera system

Sheet-film camera

Fully automatic separate microprocessor control unit with parallel bidirectional data link to host computer

Film capacity:

- max. 40 sheet films 3.25" x 4"
- or 20 sheet films 65 x 90 mm
- or 20 plates

Exposure time:

- Fully automatic measurement or manual input
- Integral measurement over camera collector or central measurement by electron density measurement on camera collector or focusing fluorescent screen

Display of exposure time on monitor

Multiple exposure

The following data are automatically imprinted on the negative:

- User initials
- Negative number
- Magnification, μm scale bar or spectrum magnification, camera length, high voltage, energy loss (δE); alternatively current of exposure meter 2, defocus or tilt angle
- Date
- Free input from keyboard (16 characters)

Output of data by printer or storage on hard disk with additional comments (**option**)

Automatic focus, tilt angle and exposure time series (**option**)

Shutter speed range

0.2 to 100s for exposure time measurement,
0.2 to 300s for exposure time input

Display of film supply on monitor

The specifications are valid for the base instrument.

Expansion of the instrument by options may change these values. Specifications subject to change.

12

Registers

Table of contents

12	Registers	
12.1	Abbreviations and Technical Terms	12-3
12.2	Index	12-6

12.1 Abbreviations and Technical Terms

ACP	A chromatic P lane
ADJ	Adjust
AIS	A utomatic I llumination- a perture S election
Be	Beryllium
BF	B right F ield
BSE	B ack S cattered E lectrons
BV-Kamera	Image intensifier camera
CAL	Calibrate
CAM	Camera
CBED	C onvergent B eam E lectron D iffraction
CL	C amera L ength
CO	C ross- O ver
CT	C ryo T rap
ΔE (δE)	Energy Loss
DF	D ark F ield
DIFF	Diffraction
DSA	D igital S canning A ttachment
EDX	E nergy D ispersive X -Ray Analysis
EEL	E lectron E nergy- L oss
EELS	E lectron E nergy- L oss S pectroscopy
ELD	E lectro L uminescence D isplay
EM	E lectron M icroscope
ESD	E lectron S pectroscopic D iffraction
ESI	E lectron S pectroscopic I maging
EVAC	Evacuation
GON	Goniometer

HM	H igh M agnification
HR-Mode	H igh- R esolution-Mode
IGP	I on g etter p ump
Ill.	I llumination
LA	L ow A ngle
LCD	L iquid- C ystal- D isplay
LED	L ight- E mitting- D iode
LM	L ow M ag
LM-Mode	L ow- M agnification-Mode
M	M agnification
M-Mode	Magnification-Mode
MAG	Magnification
MDF	M icro D osis F ocussing
MIS	M anual I llumination-aperture S election
OPF-Lens	O bjective P refield-Lens
PAR	Parameter
PGM	Program
PMT	P hotomultiplier Tube
RAM	R andom A ccess M emory
RP	R otary P ump
SA	S electd A rea
SAESD	S electd A rea E lectron S pectroscopy D iffraction
SE	S econdary E lectrons
STEM	S canning T ransmission E lectron M icroscopy
STIG	Stigmator
TEM	T ransmission E lectron M icroscope
TEM-III.	TEM Illumination
TMP	T urbomolecular p ump
UTI	Utilities

VAC	Vacuum
VENT	Ventilation
ZIP	Zoom Image Plane

Version 3.20

12.2

Index

3.5" floppy disk drive	1-66
35MM CAMERA menu	3-83 - 3-86
5-Loch-Blende (AIS-Blende)	1-27
A	
Accelerating voltage	
technical data	11-3
Adjustment of filament	6-11
Adsorption trap	1-46
AIS	
selection of	4-21
AIS ADJUST menu	3-47 - 3-51
AIS adjustment	5-3 - 5-19
Technical principle	5-3
AIS control	1-29
AIS OFFSET	
storage of	5-12
Alignment in LM mode	5-3 - 5-41
Alignment without adjusting aid	5-20 - 5-41
Anode exchange	6-6
Anticontaminator	1-48, 1-78
Aperture drive	1-80
Aperture exchange	6-17 - 6-19
Aperture removal	6-17
Aperture size	
illumination system (technical data)	11-4
APERTURES menu	3-30
APERTURES, menu	3-30
Assembly of filament holder	6-10
Automatic defocusing modes	11-5
B	
Backup floppies, preparation of	6-22
Basic settings after turn-ON	4-7 - 4-17
Beam Alignment	4-12
Beam alignment, optimization of	5-28, 5-29
Beam deflection (shift)	
illumination system (technical data)	11-4
Beam incidence	
adjustment of	5-31
Beam incidence, adjustment of	4-14
Beam path in AIS mode	1-28
Beam stop	1-79
Beryllium in the base instrument	2-4
Block diagram computer system	1-6
Brightfield imaging	4-50
C	
CALIBRATION menu	3-18, 3-19
Calibration to factory-set values	5-20
Calibration values, call of	5-20
CAM SETTING menu (sheet film cam.)	3-87 - 3-90

CAM SETTING (35mm camera) menu	3-91 - 3-93
Camera adjustment	4-62
Camera length	
imaging system (technical data)	11-7
CAMERA menu	3-79 - 3-96
Camera system	11-13
Care of specimen holders	6-15, 6-16
Care of vacuum pump	6-20
Ceiling height	10-4
Centration of SPOT illumination	5-21, 5-22
Centration of TEM illumination	5-21, 5-22
Change between specimens	4-28
Cleaning	2-13
Cleaning instructions for specimen holder	6-16
Cleaning the filter mats in the power supply cabinet	6-21
Coarse adjustment	5-14 - 5-19
Compressed-air supply	10-9
Computer system	1-5 - 1-7
Condenser aperture	1-77
Condenser aperture exchange	6-19
Control field BRIGHTNESS	1-73
Control field FOCUS	1-73
Control field GUN	1-71
Control field ILLUMINATION	1-72
Control field IMAGE	1-70
Control field panel illumination	1-72
Control monitor	1-74
Control panel	
left	1-68 - 1-70
Convergent Beam Electron Diffraction	4-58
Conveyance, means of	10-3
D	
d E menu	3-103 - 3-110
d E PARAMETERS menu	3-106, 3-107
Darkfield imaging	4-52
DARKFIELD menu	3-44, 3-45, 3-46
Data memory, separate	1-58
Data storage in a USER file	1-59
Diffraction	4-54 - 4-60
Diffraction length selection	4-23
Display illumination switch-off	3-8
Doors, dimensions of, on transport passages	10-4
E	
EDX rods made of beryllium	2-4
Electrical centration	5-21
Electrical safety	2-9
Electrode cleaning	6-7- 6-9
Electromagnetic image shift system	
imaging system (technical data)	11-7
Electron optics	1-8 - 1-41
EM system turn-OFF	4-73
Emission current	
adjustment of	4-18

Error messages on EL display	4-79
ESI imaging modes	
Contrast tuning of thick specimens	4-47
Elastic imaging	4-46
Electron-spectroscopic imaging of thin specimens	4-48
Element-spectroscopic imaging	4-49
Eucentric tilt	4-38
EXPOS. SERIES menu	3-94 - 3-96
Exposure interrupt	3-6
Exposure time	
(sheet-film camera)	11-13
Extension	1-64
F	
Filament centration	5-23 - 5-27
Filament centration in DIFF mode	5-25
Filament centration in IMAGE mode	5-23
Filament current	
adjustment of	4-18
Filament exchange	6-3 - 6-5
Filament type, filament heating current, adjustment of	6-13
File handling for external processing	1-59
Film capacity	
(sheet-film camera)	11-13
Fine adjustment of entire system	5-6 - 5-13
First aid in case of accidents and fire	
involving Be	2-5
Fluorescent screen, large	1-79
Fluorescent screen, small	1-79
Fluorescent screens	1-52
technical data	11-9
FOCUS PARAM. menu	3-38
FOCUS PARAMETERS menu	3-38 - 3-43
Focusing modes	11-5
Function keys	1-74
G	
Gaussian focus	
Adjustment of	4-39
GON PAR menu	3-72, 3-73
Goniometer	1-49 - 1-78
use of the	4-30
GONIOMETER menu	3-68 - 3-78
Goniometer settings	4-37
Gun	1-78
technical data	11-3
Gun lift	1-78
GUN menu	3-59 - 3-67
GUN PAR menu	3-63 - 3-67
H	

HELP menu	3-4
High-voltage selection	4-6
High-voltage unit	1-56
Host computer	1-7
HR mode	1-33
I	
Illumination adjustment in LOW MAG (LM) mode	1-31
Illumination adjustment MAG mode	1-25
Illumination correction, adjustment of	5-36
Illumination direction	1-20
Illumination mode	1-17
Illumination program	1-9
Illumination shift	1-20
Illumination stigmator, adjustment of	5-33, 5-34, 5-35
SPOT mode	5-35
TEM mode	5-34
Illumination system	1-16, 11-3, 11-4
Illumination system, adjustment of	4-9
Illumination tilt	1-20
Illumination-aperture selection with TEM illumination	
Magnifications as of 6,300x (AIS mode)	1-27
magnifications up to 4,000x	1-25
Image brightness	
adjustment of	4-19
IMAGE menu	3-11 - 3-113
Imaging astigmatism, compensation of	4-15
Imaging plane, adjustment of optimum	5-30
Imaging program	1-9
Imaging stigmator	
adjustment of	5-32
Insertion of condenser aperture	4-7
Installation area	10-5
Installation place requirements	10-4 - 10-10
Instrument control and operation	11-10, 11-11
Instrument data	
Sheet-film camera	1-54
Instrument parameters printout	3-7
INTERF. SETUP, menu	3-35 - 3-37
INTERFACE SETUP menu	3-35 - 3-37
Ion getter pump	1-46
K	
Key switch	1-66
Keyboard	1-75
Keyboard functions	3-6 - 3-8
L	
LENS PROGRAM menu	3-22 - 3-25
Lens programs	
imaging system (technical data)	11-7
Licence agreement, software	2-3
Loading user data	
Loading user data from a floppy disk	4-71

Loading user data from hard disk	4-72
Lock-in of specimens	4-26
Low magnifications	
LM range adjustment	4-32
Low-angle diffraction	4-60
M	
MACRO menu	3-26 - 3-29
Magnetic strayfield	10-6
Magnification	
imaging system (technical data)	11-7
Magnification selection	4-22
Main menu	3-11 - 3-14, 3-57, 3-58
Maintenance	2-12, 2-13
Maintenance, important notes on	2-12
MATRIX menu	3-77, 3-78
MEASURE menu	3-56 - 3-58
Mechanical condenser aperture alignment	5-22
Menu guidance	3-3, 3-4
Menu START	3-9, 3-10
Menüübersicht	3-5
MICRO DOSE FOCUSING menu	3-52 - 3-55
Microbeam diffraction	4-57
Microscopy	4-24 - 4-44
Mid-position adjustment	
goniometer	4-37
N	
Nanoprobe	4-57
Nitrogen supply	10-9
O	
Objective lens	1-34, 11-5
Objective lens aperture	1-78
centration of	5-32
insertion of	5-32
Objective lens aperture diaphragm	
Objective lens (technical data)	11-5
Objective lens aperture diaphragm, centration of	4-15
Objective lens apertures, selector apertures,	
exchange of	6-18
Opening specimen and filament chambers	6-4
Operating controls	1-65
Operating controls - Goniometer positioning	1-67
Operating controls - monitor	1-74 - 1-76
Operating field SCREEN LIFT	1-69
Operating panel	
	right 1-71 - 1-73
P	
PARAMETERS, menu	3-15 - 3-58
Photography	4-61 - 4-68
PL-CAMERA menu	3-79 - 3-82
POSIT. SERIES menu	3-74 - 3-76

Power supply cabinet	1-82
Precepts, important	2-10
Prevacuum signal lamp	1-78
Probe size	
illumination system (technical data)	11-4
Prohibitions, important	2-11
Protection from electric shock	2-10
Pump column cooling trap	1-46
Pumpdown of camera chamber	4-65
Pumpdown of specimen and filament chambers	6-13
R	
PARAMETERS, menu	3-15 - 3-58
Photography	4-61 - 4-68
PL-CAMERA menu	3-79 - 3-82
POSIT. SERIES menu	3-74 - 3-76
Power supply cabinet	1-82
Precepts, important	2-10
Prevacuum signal lamp	1-78
Probe size	
illumination system (technical data)	11-4
Prohibitions, important	2-11
Protection from electric shock	2-10
Pump column cooling trap	1-46
Pumpdown of camera chamber	4-65
Pumpdown of specimen and filament chambers	6-13
S	
Safety installations	2-9
Safety precautions for the use of beryllium	2-4
Safety precautions for the use of liquid nitrogen	2-6
Screening	
settings before	4-31
systematic	4-35
Selected-area diffraction with AIS apertures	4-55
Selector aperture	1-78
SER EELS menu	3-108 - 3-110
Service contract	2-3
Settings on the microscope	4-18 - 4-23
Sheet-film camera	1-53 - 1-55, 11-13
Shutter housing	11-9
Shutter speed range	
(sheet-film camera)	11-13
Single exposures	4-61
Specimen changer	1-78
Specimen exchange	4-24
Specimen holder	
technical data	11-6
Specimen plane	11-6
Specimen position, storage of	4-36
Specimen positions	4-36
Specimen rod	1-78
Specimen stage	
technical data	11-6
Spectrometer adjustment	4-7

Speed adjustment	
goniometer	4-37
SPOT astigmatism, compensation of	4-11
SPOT illumination	1-18
SPOT illumination	1-31
Status messages of vacuum system	4-74
Stigmator values, adjustment of	5-38
Stigmators	
imaging system (technical data)	11-7
Storage	10-3
Storage of user data	
Storage on floppy	4-71
Storage on hard disk	4-70
Stored specimen position, relocation of	4-36
Subcomputers	1-7
Supplementary function encoders, operating panel right	1-75
Supply and disposal	10-8
Supply, electrical	10-8
Switch-ON	4-3 - 4-5
T	
TEM illumination	1-17, 1-31
The imaging system	1-34
Tool kit	6-12
Turbomolecular pump	1-46
TV camera port	
35mm camera	1-79
U	
Ultrasonic bath for all parts	6-9
Unloading	10-3
Unpacking	10-3
UPPER SYSTEM	
adjustment of	5-11
USER menu	3-20, 3-21
UTILITIES menu	3-31 - 3-34
V	
VACUUM menu	3-97 - 3-102
Ext. vacuum system (2 IGP's)	3-100 - 3-102
Standard vacuum system	3-97 - 3-99
Vacuum system	1-42 - 1-47, 11-12
Ventilation of camera chamber	4-65
Ventilation of specimen and filament chambers	6-4
Vibration, mechanical	10-7
Viewing binocular adjustment	4-45
Viewing binoculars	1-51
Viewing chamber	11-9
viewing head	11-9
Viewing microscope	1-79
W	

Waste disposal of beryllium parts	2-5
Waste-gas line	10-9
Water cooling	10-10
X	
X-ray safety	2-8