7 CM300 ELECTRICAL AND MECHANICAL CONTROLS – LOCATION AND DESCRIPTION

7.1 PANEL CONTROLS AND INDICATORS

- Pushbuttons (except for the Microscope ON/STANDBY/OFF buttons which are internally illuminated to specific safety requirements) operate in association with a green indicator lamp, which, unless otherwise specified, illuminates to show an active condition.
- Stepped and continuously variable rotary controls are referred to as knobs.
- Preset controls are referred to as presets.

7.1.1 Left-hand control panel (see Fig. 7.1)

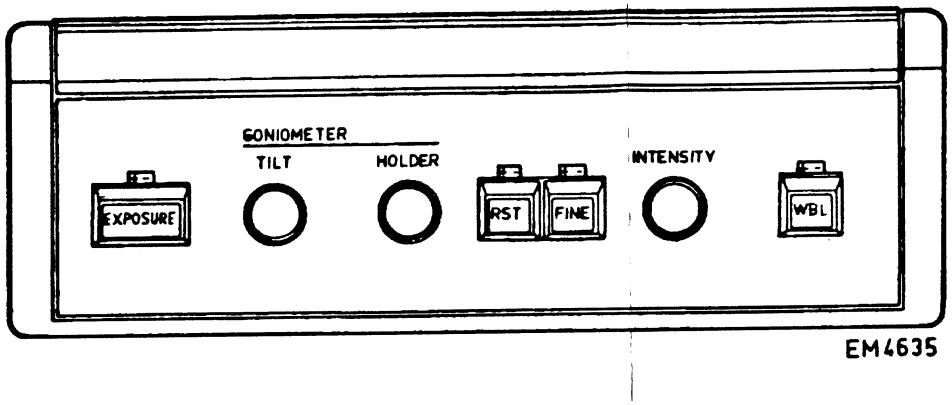


Fig. 7.1

S274) EXPOSURE/Normalization button

Green light on - triggers a TEM exposure procedure.
Green light off - triggers a normalization procedure for the magnification range.

GONIOMETER controls

R2) TILT knob
Controls tilt motor drive.

R1) HOLDER knob
Controls internal movement of special holders, e.g. double tilt and rotation.

S375) RST (Reset) button
Resets intensity to give fully focused illumination.

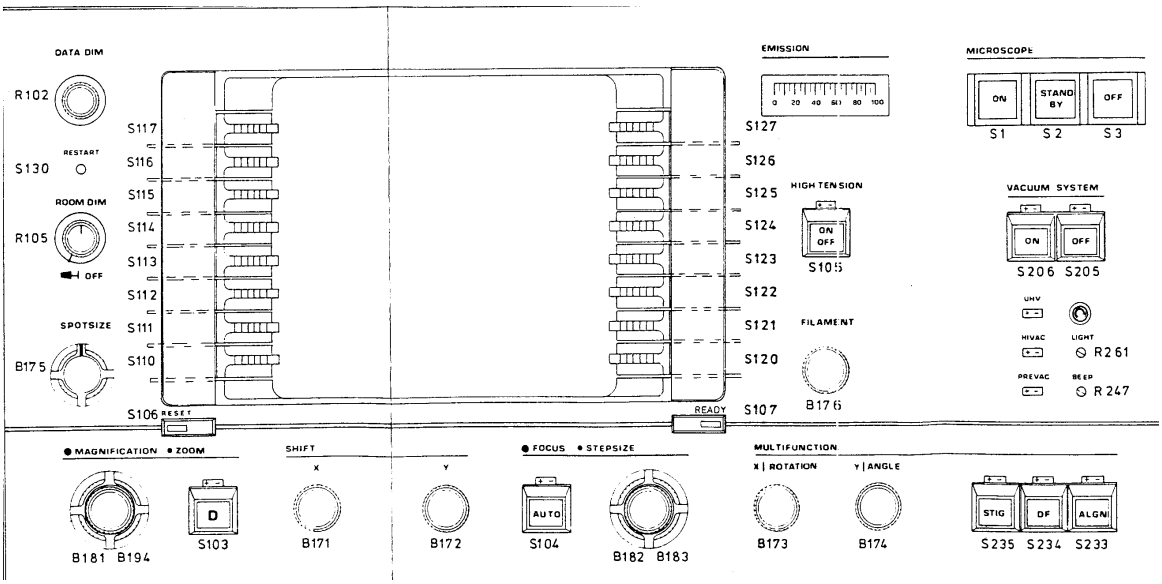
S376) FINE button
Selects:
- Fine intensity control range - green light on.
- Coarse intensity control range - green light off.

S384) INTENSITY knob
Controls the current density on the specimen and the brightness on the screen.

S377) WBL (Wobbler) button
Controls the Wobbler focusing aid.

7.1 .2 Right-hand control panel - basic TEM system (Fig. 7.2)

MICROSCOPE controls



S1) ON button
White light on - STANDBY button is ON.

S2) STAND BY button
Yellow light on - ON button is ON.

S3) OFF button
Red light on - ON button is ON.

VACUUM SYSTEM controls
S206) ON button
Switches the vacuum system on.

S205) OFF button
Switches the vacuum system off.

UHV indicator
Green light on when operational ultra-high vacuum is attained.

HIVAC indicator
Green light indicates:

- Standby mode when VACUUM SYSTEM ON button is not operational.
- That the high-vacuum pumping sequence is in progress when VACUUM SYSTEM ON button is operational.

PREVAC indicator
Green light on when pre-vacuum pumping is in progress.

R261) LIGHT preset
Controls the brightness of the panel lights.

R247) BEEP preset
Beep volume control

EMISSION indicator and controls
Emission current indicator Scaled from 0 to 100 μA

S105) HIGH TENSION ON/OFF button
Switches the H.T. on and off.

B176 FILAMENT current knob
Controls the filament current level.

R102) DATA DIM knob
Controls brightness of data monitor screen.

S130) RESTART preset button.
Restarts computer.

R105) ROOM DIM/OFF knob
Controls the room lighting level.

B175) SPOT SIZE knob
Selects spot size. This defines the total beam current.

MAGNIFICATION/ZOOM Controls
B181) Outer knob
Controls image and diffraction-pattern magnification.

B194) Inner knob
Controls zoom function.

S103) D (Diffraction) button
Selects:

- Diffraction mode - green light on
- Imaging mode - green light off

SHIFT controls

B171) X knob
B172) Y knob
Control:

- Beam shift in TEM modes.
- Image shift in STEM modes.

FOCUS/STEPSIZE controls

S104) AUTO pushbutton
Selects automatic focus for the specimen at the eccentric height.

B182) Focusing knob
Controls the focusing lens current.

B183) Step size selector
Selects the amount of focus current change.

MUL TIFUNCTION controls

B173) X/ROTATION knob
Continuous control used in conjunction with Wobbler, S'FlGmator, Dark-Field and AliGNment buttons.
B174) Y/ANGLE knob
Continuous control used in conjunction with Wobbler, STlGmator, Dark-Field and AliGNment buttons.

B235) STIG (Stigmator) knob

Assigns stigmatic function to MULTIFUNCTION X and Y knobs

S234) DF (Dark-Field) button
Assigns beam tilt function to MULTIFUNCTION X and Y knobs.

- Dark-Field mode - green light on
- Bright-Field mode - green light off

S233) ALGN (Alignment) button
Selects ALIGNMENT selection page and assigns priority alignment to MULTIFUNCTION X. and Y knobs

S106) RESET key
Resets error messages and adjusts settings to mid-position where applicable.

S107) READY key
Returns to previous operational mode or steps forward in alignment procedures.

Softkeys (Left S110-S117)
For data and function selection from display pages (Right S120-S127).

7.2 MECHANICAL CONTROLS

The reference numbers associated with each control refer to annotations in Figs. 7.3 to 7.8 inclusive.

Caution! All mechanical controls operate smoothly and can be adjusted without particular effort. If a high mechanical resistance is encountered, do not force the control otherwise damage may result. First find the cause of the resistance and, if necessary, call your local service organization.

7.2.2 Lens apertures (Fig. 7.6)

The following controls are identical for the:

- 2nd condenser lens **C2**
- Objective lens **Obj.**
- Diffraction lens **Diffr.**

111 Aperture selector

This has four click stop positions. In each position, one of the four apertures held in the holder is positioned on the microscope axis. Accurate centering of each aperture with respect to the microscope axis is carried out using the aperture-centering controls.

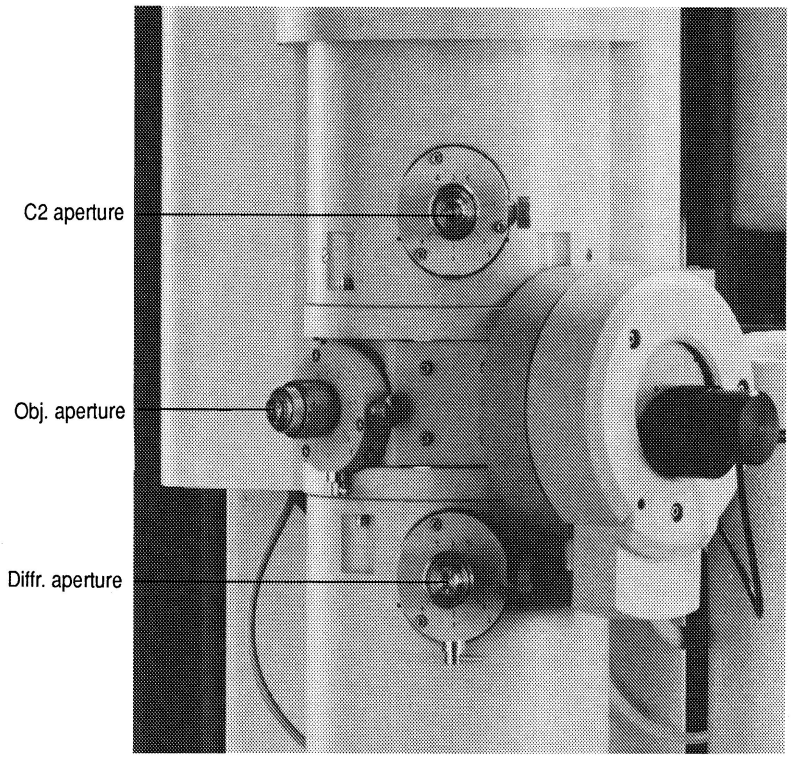


Fig. 7.6, Lens aperture controls

112 Aperture-centering controls

113 These knurled knobs operate in two perpendicular directions to center the aperture with respect to the microscope axis.
The range of movement is limited by end stops so that the aperture cannot be moved far from the centered position.

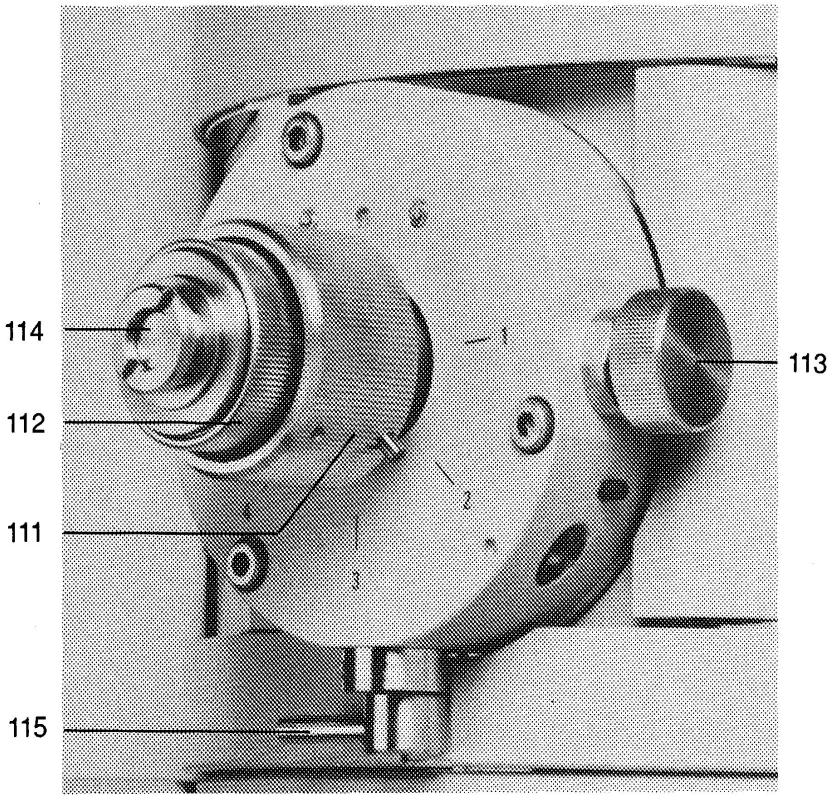
Caution! Do not try to force the controls beyond these stops.

114 Aperture holder

Contains four apertures, which can be introduced successively into the beam using the selector. The holder itself can be removed from the microscope column (once air has been admitted) by first unscrewing the knurled end and then carefully pulling it straight out. When replacing the holder ensure that the guide pin enters the slot. Push the holder in as far as it will go, then firmly screw up to the end.

115 Aperture-displacement lever

This lever displaces the aperture holder into and out of the beam. To remove the holder from the beam, rotate the lever to the right. To replace the holder in the beam, rotate the lever to the left. Recentering of the last aperture selected is generally unnecessary when moving the aperture into and out of the beam using the displacement lever.



7.2.3 Viewing chamber (Fig. 7.7a and 7.7b)

121 Central beam-stop insertion knob

This knob brings the beam stop into position to intercept the central beam of a diffraction pattern. To operate, turn the knob 45^0 counter-clockwise and push it in as far as it will go. The beam stop is also useful for focusing the binoculars on the small screen (focus on the sharp beam-stop shadow cast on the small screen).

122 Central beam-stop adjuster knob

Rotation of this knob adjusts the length of travel of the beam stop into the center of the beam.

125 Binoculars-securing knob (optional)

When this knob is loosened, the binoculars can be pivoted to the left of the viewing chamber, out of the line of sight.

126 Main-screen lever

This raises and lowers the main screen out of and into the beam. When lifting the lever:

- The electromagnetic shutter is closed first.
- At 30^0 a stop is felt. If the lever is released now, the shutter will open and the image can be viewed closely. If upward pressure is maintained on the lever, the shutter will remain closed.
- At 90^0 the screen is vertical and allows use of the plate camera (or detector below that, such as the optional TV camera or the STEM BF/DF detectors).
- If the small screen is in use, it is automatically moved out of the beam together with the main screen.

Note: Exposure measurements using the main screen must be made with the screen in the horizontal position. It must then be raised to the vertical position without the shutter being allowed to open at the 30^0 position, otherwise an error in the exposure time will be made.

127 Small-screen lever

This lever moves the small screen into and out of the beam. When the screen is brought into the beam it is automatically switched to the exposure measuring system.

Note: If the small screen is used to measure the exposure time, it must be removed together with the main screen be operating only the main-screen lever 124 or an error in the exposure time will be made.

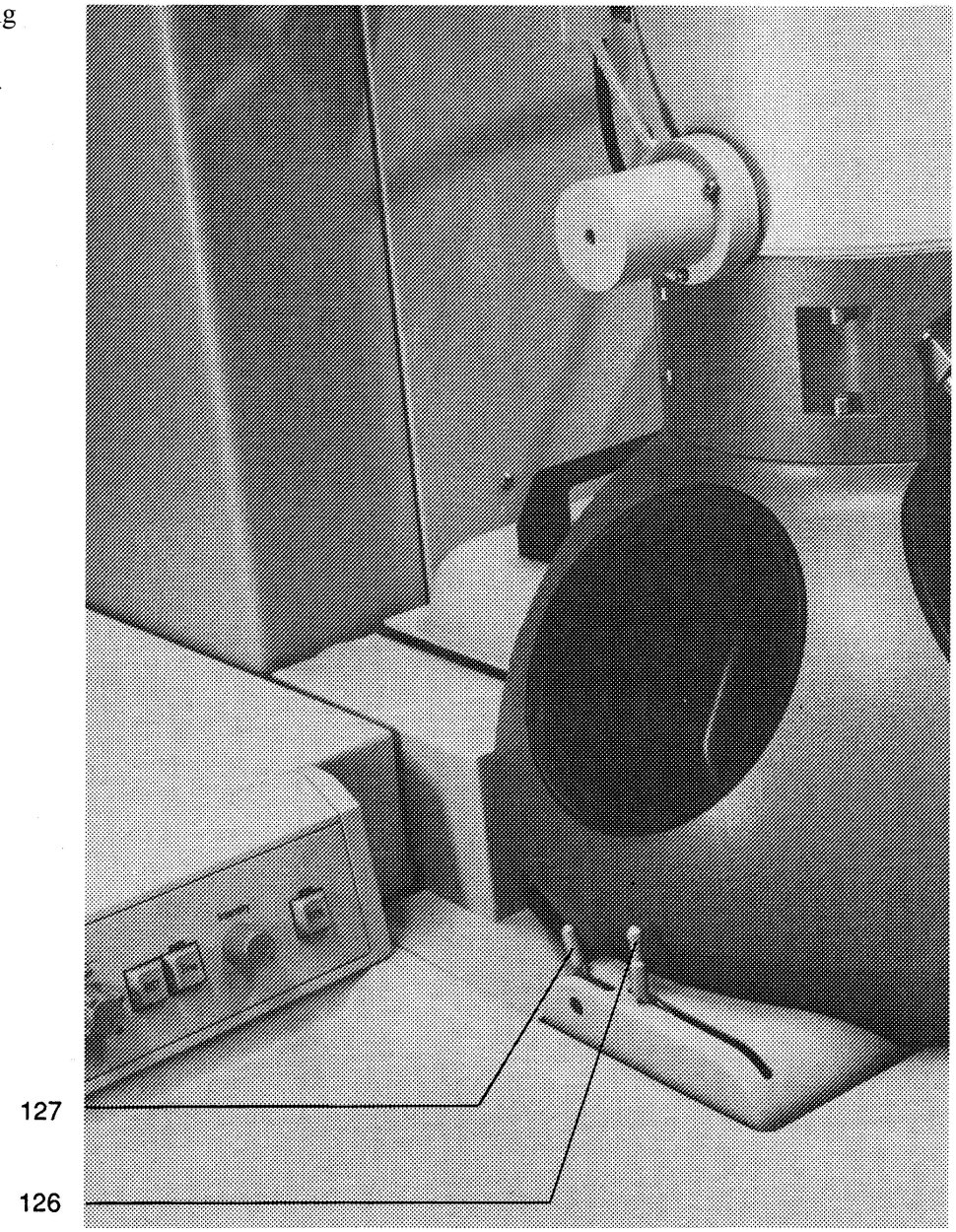


Fig.7.7a Area, Viewing - left

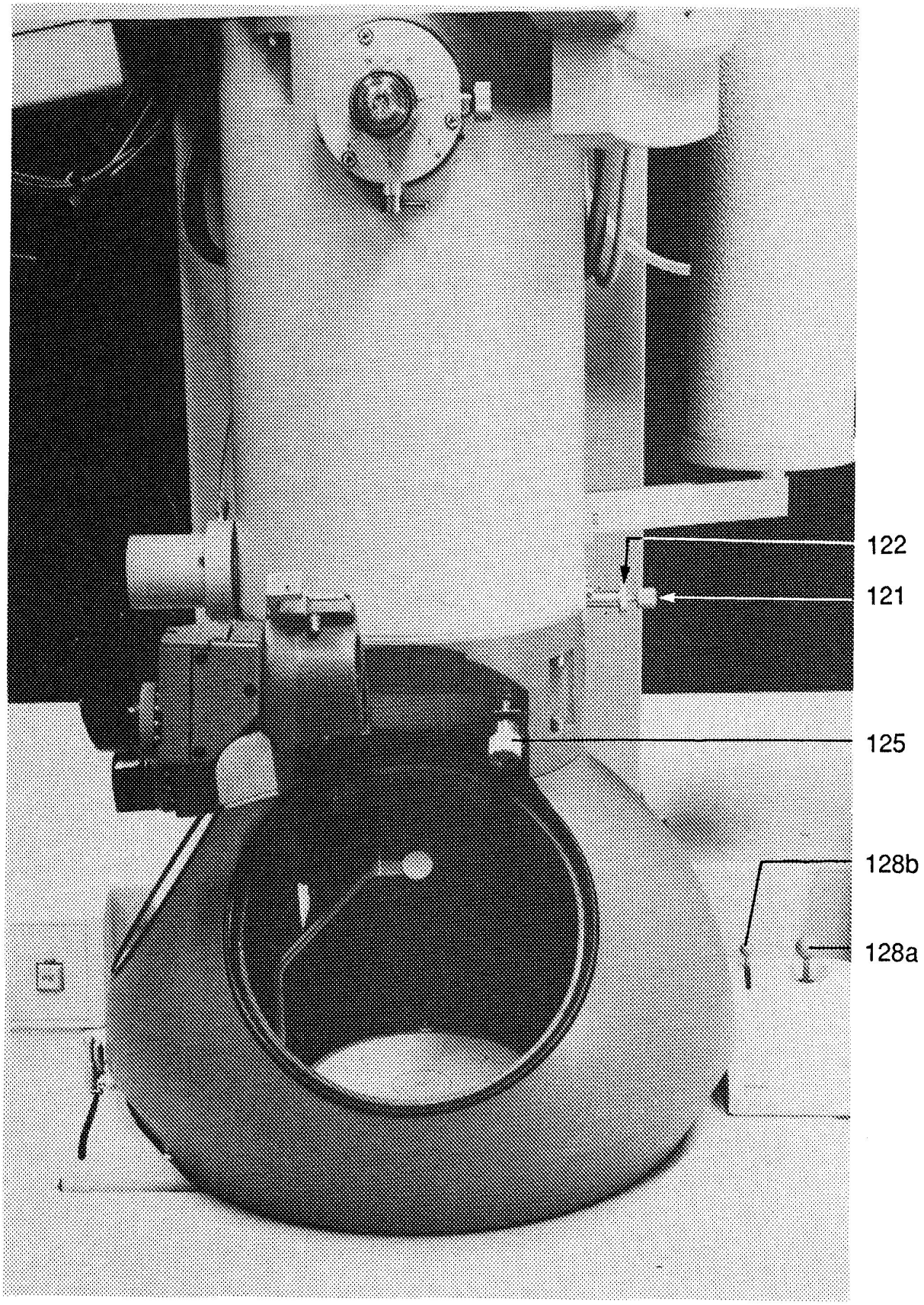


Fig. 7.7b Viewing chamber - right

128 Joystick pad for specimen movements

a) XY joystick provides continuous displacement in X direction (direction of the tilt axis) and the perpendicular Y direction. Speed of the movement and other parameters can be changed by activating the Compustage pages (Softkey COMPUSTAGE, see Chapters, 6)

b) Z joystick for specimen movement in Z direction to adjust specimen height..

7.3 INDEX OF SOFTKEY LABELS WITH DESCRIPTIONS

7.3.1 Softkey labels TEM

LABEL	MODE/ACTION/SELECTION
ALIGNMENT	ALIGNMENT selection page
ALL AIR	Admits air to all sections of the column
AUTO	Automatic exposure timing of the TEM camera. In conjunction with DET CONF, AUTO defines the default diffraction/image shift onto detectors placed at the base of the projection chamber depending on the microscope mode of operation
AUTOCON-I	Defocus possibilities: magnification-dependent in AUTOCON 1 - 5 and fixed underfocus in SCHERZER
AXIS-cal	Axis calibration for stereo measurements
A-WOBBLER	α-tilt continuously changed between $+15^0$ (TWIN, SuperTWIN)
beamcoils PIVOT PT X, Y	Direct alignment of beam coils pivot points
BF/DF	BF/DF STEM detector installed/not installed
C1	First condenser lens in free lens control
C2	Second condenser lens in free lens control
C2STIGM	C2 stigmator alignment procedure or direct alignment
C2 WOBBLER	Wobbler for C2 aperture alignment
CAM AIR	Admits air to projection chamber/plate camera
CAM INIT	CAMERA INITIATION page
cam type PLATE 35 mm	Inactive (PLATE camera always selected)
cal	Calibrate submode in measuring
CLEAR	Pressing it twice; the currently selected position will be cleared
CLEAR ALL	Pressing it twice, all stored positions will be cleared
CENTRAL	Allows the user to inform the system which detector is placed on-axis at the base of the projection chamber
COL AIR	Admits air to column section
COLUMN	Column alignment procedure
COMA FREE	Coma-free objective lens centering

LABEL	MODE/ACTION/SELECTION
COMPUCTRL COMPUSTAGE	Lead to Compustage control page
CONDITIONING	HT setting for gun conditioning
CONFIGURATION	CONFIGURATION page
CRYO	Leads TO vacuum functions for cryo microscopy
CURR INCR DECR	Current modulation for objective rotation centredata intExposure intensity of plate numbering device
DECR	Parameter decreases one step each time the key is pressed
DET ALIGNM	Aligns the Dp/image with the BF/DF near axis detector or the on/off-axis TV system
DET CONF	Allows the user to input current configuration of detectors positioned at THE base of the projection chamber
df mode X-Y CONE	Rotation and tilt type of beam tilt in dark-field mode, conical operation
df mode X-Y CONE	Dark-field beam tilt mode in x-y operation
DIAGNOSTIC PROGRAM	Hardware diagnostic program (for service procedures only)
DIF	Diffraction lens in free lens control
DIF ALIGNM	Direct alignment of diffraction pattern for all camera lengths
DIF SHIFT	Direct alignment of diffraction pattern
DIF STIGM	Diffraction lens stigmator alignment procedure
DISPLAY	CURRENT READOUT display page for all lens and deflection CURRENTS coils
DOUBLE EXP	Double exposure on the TEM camera
EDX PROT	COLUMN AIR and LM-mode are prohibited
emulsion LOW HIGH INCR DECR	Sensitivity of the film emulsion (two different sets can be entered per camera)
ENABLED	Switches goniometer control unit (GNCB) on/off
ENTER	Enters a position in the measuring mode or a lens setting in the free lens control mode

LABEL	MODE/ACTION/SELECTION
exp delay INC 0.5 s DECR	Required shutter delay
exp factor INC mode 1.5 DECR	Required factor by which the measured exposure time in the low- dose focus state is multiplied to determine the exposure time in the exposure mode
exp mode SINGLE EXP DOUBLE EXP SERIES HOLD	Exposure mode for the TEM camera . ● single (this is the default setting) ● double ● fixed or through-focus series ● prevents switching back to the default setting following request for Double or Series exposure
exp no	Exposure number to print on photo
exp time AUTO TIMER MANUAL HOLD	Method of timing for a photo procedure: . ● automatic measurement and exposure when recording ● open shutter manually and measure elapsed time ● set exposure time manually (for example in Diffraction mode) ● holds a measured exposure timing method
EXPOSURE	Exposure state in the TEM low-dose mode (excludes FOCUS and SEARCH)
FIL limit	Sets maximum filament heating level
FIX FOCUS	Photo series with fixed focus setting (TEM camera) Focus state in the TEM low-dose mode (excludes EXPOSURE and SEARCH)
FREE CONTROL	Free control of high tension in steps of 50 V to 20 kV
FREE LENS CONTROL	FREE LENS CONTROL page
GONIO AXIS	Goniometer service alignment procedure
GUN	Gun alignment procedure
GUN SHIFT	Gun shift direct alignment
GUN TILT	Gun tilt direct alignment
GUN AIR	Admits air to gun section
IGP	Manual switching of the ion getter pump (for service procedures only)
IMAGE/BEAM	Performs beam/image shift calibration procedure (on service calibration page)
IMAG SHIFT	Direct alignment of image shift for different magnification ranges

im shift 1 2 zero	Electrical image shift for high magnifications with multifunction knobs MFX/Y. Two different areas can be stored in "1" and "2".
INC	A parameter is increased
increment PLATE CONT	CONT: If plate camera and 35 mm camera are used alternately, the plate numbering is automatically increased by one with every exposure independent of the camera type. PLATE: the plate numbering is only increased for every exposure if the plate camera is used, for the 35 mm camera the plate number does not change.
INT	Intermediate lens to act on in free lens control
INT ZOOM	Intensity zoom mode
INT LIMIT	Intensity limit mode
JOYSTICKS	on: XYαβ are working; off: XY Joystick, α, β are deactivated
JOYSTICK Z	on: Z joystick working; off: Z Joystick deactivated
Lab_6	Enter type of cathode installed
LOW DOSE	Image area to left or right of the central area, during exposure only
man time INCR 20 s DECR	Manual setting of photo exposure time for the TEM camera
MANUAL MANUAL PAGE	Manual setting of the photo exposure time for the TEM camera Vacuum system control, for service engineer only
MEASURING	MEASURING page
MODES	MODES page
NANO PROBE	TEM nanoprobe mode
NEAR-AXIS	Allows the user to inform the system that the BF/DF detector is situated in the near-axis position
OBJ	Objective lens in free lens control
OBJ STIGM	Objective stigmator alignment procedure
ODP	Manual switching of the oil diffusion pump (for service procedures only)
OFF-AXIS	Allows the user to inform the system that TV is situated in the off-axis position.

LABEL	MODE/ACTION/SELECTION
P1	First projector lens in free lens control
P2	Second projector lens in free lens control
PARAMETERS	PARAMETERS page
(P)EELS	(P) EELS detector installed/not installed
POST SPECIMEN SCAN	Post-specimen scan mode
READY	Page changes to operation page
RECALL	Recall of the selected position
REGISTERS DISPLAY ZAB	on: for each stored position XYZαβ are displayed off: for each stored position only XY are displayed
RESET	AB Resets α and β to zero
RESET HOLDER	Resets all axes to zero
ROT CENTER	Objective lens rotation center direct alignment
ROTATION	Rotation alignment of XY joystick to make sure that specimen moves in the same direction as that in which the joystick is held
RSET DEFOC	Indicated defocus value in the information field is set to zero. No change of focus
RSET SHIFT	An image shift is canceled
SCHERZER	Scherzer defocus
SEARCH	Search state in low-dose mode (excludes FOCUS and EXPOSURE)
SERIES	Photo series with the TEM camera
series INCR 1 DECR	Number of exposures for a photo series on the TEM camera
service CALIBRATE	Access to service calibration procedures
SINGLE EXP	Single exposure with the TEM camera
SPEED +/-	Increases (+) or decreases (-) speed of specimen movement
STEREO	Three-dimensional program when measuring
stock set value RESET	Initializes the number of available plates

LABEL	MODE/ACTION/SELECTION
STORE	Storage of the current position
SUPER TWIN	Displays type of polepieces installed when Super Twin lens installed
TEM	Conventional TEM mode/TEM calibration service procedure
TEM CAMERA	TEM CAMERA subpages (camera initiation, film and film coding initiation)
TEM LOW DOSE	TEM low-dose mode
THR-FOCUS	A photo series with varying focus settings for the TEM camera
TIMER	Exposure mode with manual opening and closing of the shutter, instrument gives time elapsed
TUNGSTEN	Enters type of cathode installed
TV	TV system installed/not installed
TV SPEED	Speed is reduced when the fluorescent screen is raised
TWIN	Enters type of polepieces installed
TWN	Mini-condenser lens in free lens control
USER	Under DET CONF, allows the user to define the diffraction/image shift onto the detector placed at the base of the projection chamber independent of the microscope mode of operation
V1 . . . 1 2	Manual operation of vacuum valves (accessible to Service Engineer only)
VACUUM	VACUUM subpages
Vacuum function	Leads to vacuum functions
VCR	Video cassette recorder
VOLT	Voltage modulation for objective rotation center
XY CTRL	Specimen relocation system (optional)
XY RECALL	on: RECALL acts only on XY; off: RECALL acts on XYαβ
XY SEPARATELY	on: only X or Y movement; off: simultaneous XY movement
Z DISPL=0	Sets Z to zero for example for eccentric height
Z DISPL USER REAL	Z-coordinate is a relative value, dependent on user setting The real Z-coordinate is displayed (absolute value)
ZOOM	Lens program with optimum focus setting

1 STARTING THE MICROSCOPE UP AND OBTAINING THE FIRST IMAGE

1.1 INSTRUMENT CONTROL LOGIC - THE OPERATOR'S CONSOLE (See Fig. 7.2)

One of the major design features of the CM300 is the simplification of the control components, which has led to a significant reduction in their number. These controls form three groups:

- Knobs
- Pushbuttons
- Keys

There are knobs, which can be turned, pushbuttons in various positions and a set of 18 keys around the control screen on the right-hand panel. Two of these keys have permanent labels (RESET and READY) but the remaining eight keys on either side of the control screen only receive labels when the microscope is switched on. Each label is displayed next to the key it describes. There follows a short explanation on the use of these controls.

Using the knobs

The controls can be explained in terms of a basic electron microscope having the primary functions of Magnification, Intensity (image brightness) and Focus (image sharpness). These functions correspond to three dedicated lenses:

Function	Preformed by
Magnification	Projector lens
Intensity	Condenser Lens
Focus	Objective lens

In modern microscopes, these lenses can be two or more lenses working together. The specific function assigned to one lens, e.g. focusing, can change when the microscope is being used under different optical conditions. However, the three basic functions will always be involved when obtaining an image and it is logical to assign the function names MAGNIFICATION, INTENSITY, FOCUS and to ensure that the correct lenses or combinations are addressed in the various microscope modes. To be consistent, there cannot be a fixed connection between the function knob and a specific lens since the lens, which is used for the function changes with the different modes selected. As an example, the lenses assigned to the focusing function are shown below. The focusing function is dependent on the optical mode of the microscope.

Mode	Focusing performed by
Imaging in M/SA magnification range	Objective lens
Imaging in LM lens magnification range	Diffraction
SA Diffraction	Diffraction lens

In the case of the scanning mode in a TEM/STEM system, the focusing functions are as shown below:

Mode	Focusing performed by
Imaging in HM magnification range	Objective lens
Imaging in LM magnification range	Second condenser lens

The CM300 uses a microprocessor to interpret input so the user does not have to record the particular optical working conditions.

The same principle as applied to FOCUS is used with the MAGNIFICATION knob to control the magnification of any type of image or diffraction pattern. The actual magnification is displayed in the information field of the control screen using the usual dimensions, i.e. .....X for the image magnification and .....mm for the magnification of the diffraction pattern related to camera length.

The Multifunction knobs

The FOCUS and MAGNIFICATION knobs use the concept of assigning various optical components to a certain knob to achieve the same function in every condition. The MULTIFUNCTION knobs expand this concept in that the function itself may change. This change can be caused automatically by the microscope control system or manually by the operator.

An example of automatic change occurs with all the alignment procedures. Most of the alignments in the CM300 can be carried out electromagnetically. When stepping through an alignment procedure, a number of different alignment functions must be performed. These functions will be automatically assigned to the MULTIFUNCTION knobs so the user only needs to use the same set of two MULTIFUNCTION knobs. The alignment instruction will say:

Center the illumination with the MULTIFUNCTION knobs

The operator may also assign functions to the MULTIFUNCTION knobs by using the STIG, DF and ALGN pushbuttons. The STIG (Stigmator) pushbutton controls the appropriate stigmator for the objective or diffraction lens and DF (Dark Field) provides beam tilt for Dark Field imaging. The ALGN (Alignment) pushbutton calls up the alignment function referred to preciously. In order to indicate that one of these functions is active on the MULTIFUNCTION knobs, the green LED above the pushbutton is lit whenever that function is selected.

Using the pushbuttons

When a pushbutton is pressed, it gives a single information pulse to the microscope control system, which then performs the requested action. To switch off or stop this action, it is necessary to press the button a second time. An example is if the STIG button is pressed, the green LED lights up and the (optically appropriate) stigmatic function will be assigned to the MULTIFUNCTION knobs. To terminate this function, the same STIG button must be pressed once again. A green LED above each of these buttons indicates if they are on or off.

A pushbutton may be switched off by the microscope when a conflict arises, e.g. when ALiGNment is selected with Dark Field on or the WoBbLer when an exposure in made. Some pushbuttons are only used to generate a singe pulse and do not need switching off. Those pushbuttons either have no associated LED or the LED does not light up. Examples are the ReSeT button to the left of the FINE INTENSITY control (this focuses the electron beam) or the EXPOSURE button when the main screen is down (performing a lens normalization).

Using the Keys and Control Screen

The third type of control element is the key associated with the Control Screen. These 16 keys are located on either side of the screen. The label for each key is displayed next to it on the screen. Because these labels can change, the keys are described as Softkey.

The Microcontroller

The control screen, softkey, pushbuttons and knobs give access to the functions of a microprocessor-based control system which records all operator inputs and directs them to the relevant device associated with the selected mode. It also ensures that user- defined settings of lenses and alignments are automatically recalled when switching between different modes. The interactive control screen and associated systems are known as the Microcontroller. The Microcontroller has two basic functions:

- Provide microscope status information
- Accept commands from the operator

The main difference between the softkeys and the pushbuttons is that the pushbuttons are used during operation in a specific mode while the Microcontroller softkeys can change the operational mode. The operator can select or change a parameter for the working mode. The Microcontroller is also used to instruct the instrument to employ some initial settings, i.e. the information to be printed on the photographic plates or details of the apertures, which are installed in the aperture holders.

A typical screen display is shown in Fig. 1.1. All such displays are headed by a title and referred to as a Page. The central part of the Page between the two vertical lines contains details of the most significant parameters of the present stale of the microscope. The text underneath Fig.1.1 explains the content of the information fields.

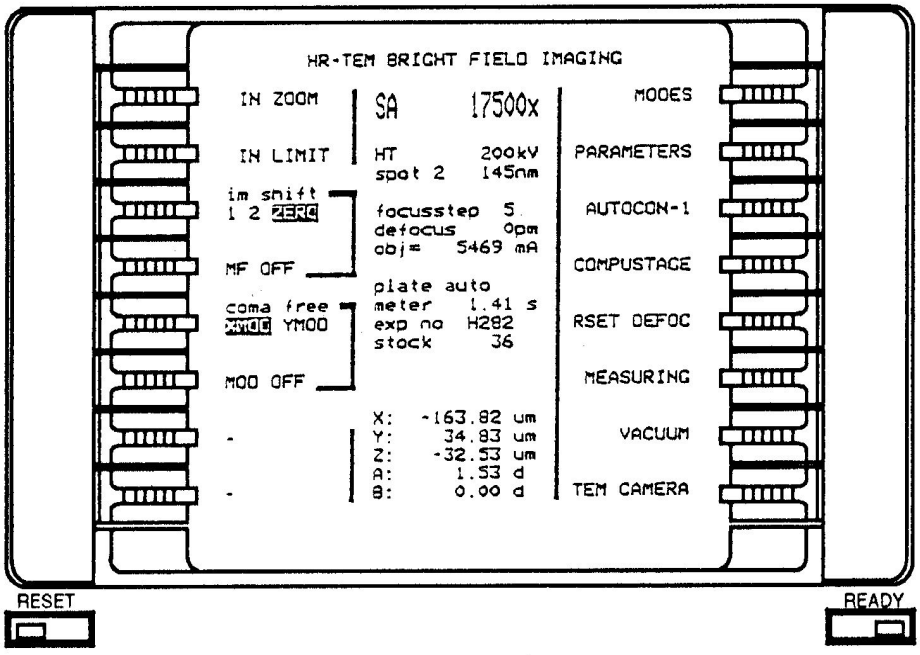


Fig. 1.1. TEM BRIGHT-FIELD page

The central information field

- **17500x** is the magnification in use.
- **SA** indicates the **S**elected **A**rea mode is in use.

- The **H.T.** selected is **200 kV.**
- The SPOT SIZE knob is set to step **2** giving a **SPOT** size of **145 nm** when the beam is focused on the specimen.
- The value of under or overfocus is given **(defocus 0 pm)**.
- The **FOCUS STEP** is the sensitivity of the FOCUS knob (focus change per click).
- The recording medium selected is the **PLATE** camera
- The exposure timer is in **AUTO**matic mode
- The exposure **METER** determines an exposure time of **1.41 s.**
- The **EXP**osure **No**. (number) of the last plate exposed is **H282** This number will be increased by one digit for each plate recorded.
- The **stock** of unexposed plates is **36**

The softkey labels and the highlight facility

The softkey labels identify the selections available to the respective keys. When a softkey is pressed, the system can acknowledge this in two ways:

- The contrast of a label is reversed, i.e. changed to black letters on a bright background (highlighting) or vice versa.
- The page content changes.

When a label is highlighted, this indicates that the corresponding function is operational. For example, INT ZOOM could be highlighted indicating that the illumination system will automatically zoom the intensity control so that the brightness on the observation screen is kept constant when changing the magnification (within a certain range). To disable the INT ZOOM feature, press the key again and the highlighting will disappear.

Setting parameters

Another page would be displayed if PARAMETERS was keyed (see Fig. 1.2). On this PARAMETERS page several operational parameters can be set to the desired value. Again, the value, which is currently valid, is highlighted.

In this example, the EMISSION is set to 1 and the HIGH TENSION is set to 200 kV. To change these parameters, press the left-hand key to move the highlight to the left and the right- hand key to move the highlight to the right.

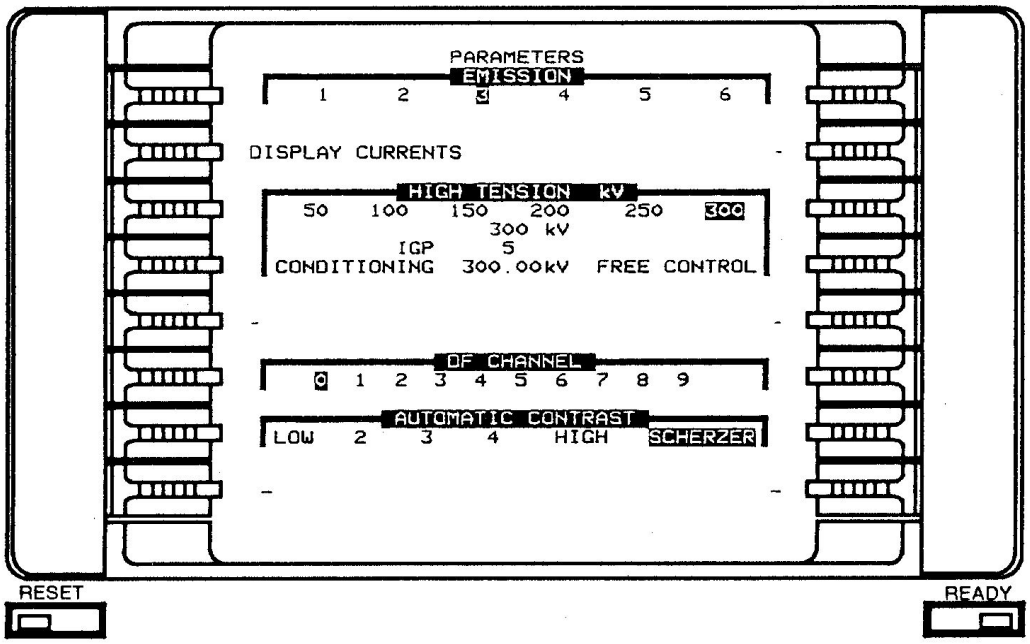


Fig. 1.2, PARAMETERS Page

The CAMERA INITIATION page (see Fig.1.3 overleaf) shows another way of setting a parameter. The Exposure number printed on the last plate used is E009. This number appears on the central information field. It also appears under the EXP NO label on the left-hand side of the screen. To begin with another exposure number, key the appropriate figures using the associated softkey.

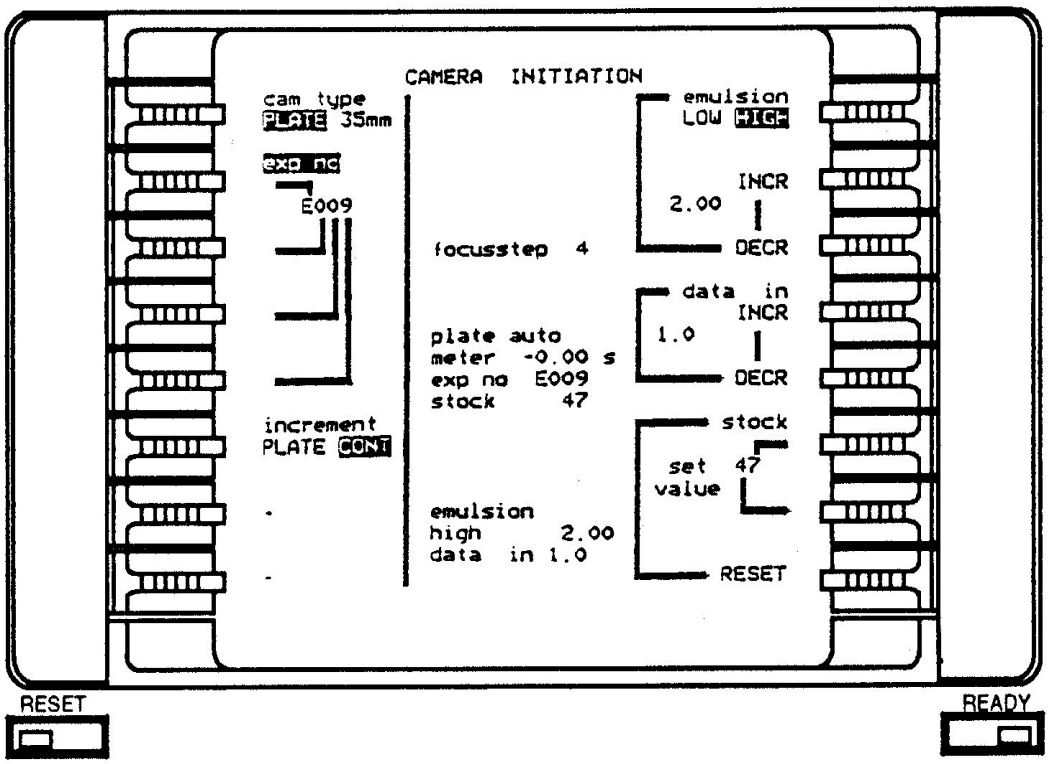


Fig. 1.3, CAMERA INITIATION Page

RESET, READY and the LEDS

When the operator has finished an action and wishes to continue, the READY key should be pressed. This will occur, for example, after having set the PARAMETERS or after carrying out the CAMERA INlTiation. The instrument will then return to the operational page displayed previously.

In an alignment procedure, the READY key is used to instruct the Microcontroller that a particular step has been carried out and that the next should be taken.

The RESET key is used to clean the control screen after the Microcontroller has issued a message that has overwritten a part of the current page. The RESET key can also be used to set the MULTIFUNCTION knob values to a default (central) position.

The yellow LEDS in the RESET and READY keys indicate whether these keys are active and able to respond to commands. If there is nothing to be reset or no reason to indicate that a procedure is ready to proceed further, the instrument Will not expect a READY or RESET input and the LEDS will be switched off.

The Microcontroller also uses the BEEP (sound) signal when it wishes to communicate with the operator. The BEEP will be heard when a pushbutton being pressed or a control knob being turned is inactive, e.g. the filament when the high tension is still off or when a knob has reached the end of its range. There is no mechanical stop and further rotation of the knob is harmless. The BEEP signal ceases as soon as the turning stops. When turned in the opposite direction, it is immediately in range again. (This facility applies to all knobs with the exception of the GONIOMETER control knobs on the left-hand panel). The BEEP signal is also used as a warning before the electron optical configuration of the microscope is radically changed, e.g. the LM-M magnification change and vice versa.

1.2 OPERATIONAL EXAMPLE: THE TEM BRIGHT FIELD IMAGING MODE

The following example is an introduction to the operational features of the CM300 and describes the basic steps required to obtain a TEM Bright Field image and make a TEM micrograph

1. Start the microscope up by pressing the MICROSCOPE ON button. (If more information about start up is. required, see Sect. 4.1.1).

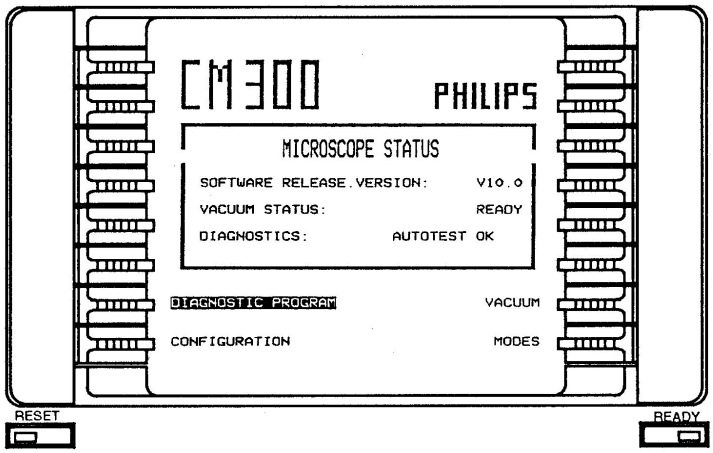


Fig. 1.4, START UP page

2. Key MODES on the START UP page and display the MODE SELECTION page.

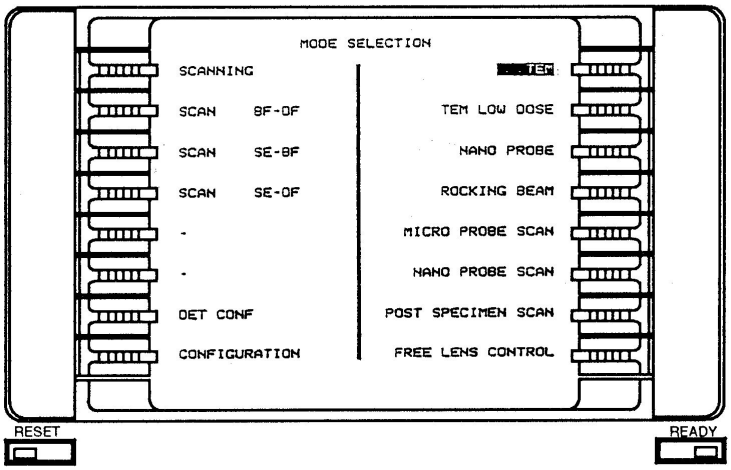


Fig. 1.5, MODE SELECTION page

Note: The page shown in Fig. 1.4 may contain different softkey labels than those shown. This is dependent on the configuration of the microscope.

3. Key TEM on the MODE SELECTION page. If TEM mode was previously selected, the letters TEM will be highlighted. Key TEM and the TEM BRIGHT FIELD page will be displayed immediately. If another mode was selected previously, the letters TEM will not be highlighted. In this case, proceed as follows:

- Key TEM once and the letters TEM will become highlighted, indicating that the TEM mode is selected.
- Key TEM a second time and the TEM BRIGHT FIELD page will be displayed (see Fig. 1.6 overleaf).

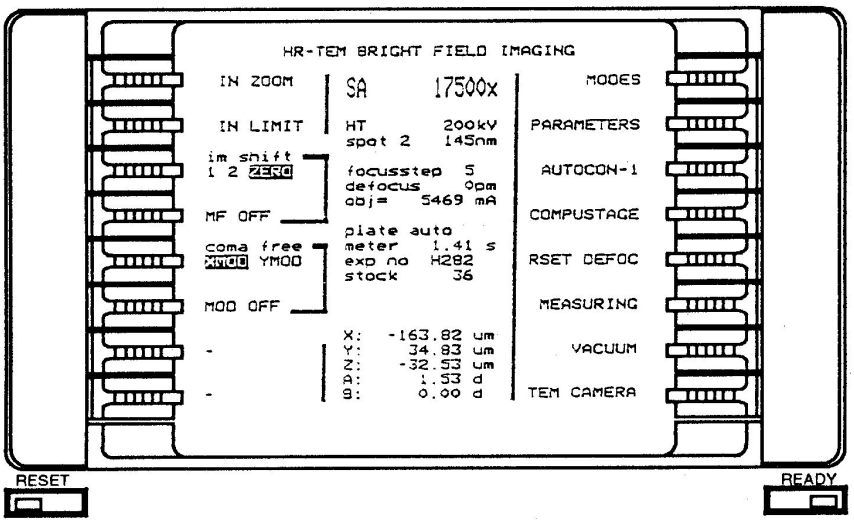


Fig. 1.6, TEM BRIGHT FIELD page

Insert a specimen holder into the microscope.

Note: If there is no specimen holder in the airlock, the gun shift is set to a maximum to ensure that no X-ray leakage can occur through the airlock. No beam will then be visible. The beam becomes visible only if a specimen holder is in the airlock.

4. Observe the information field and define the H.T. required. The H.T. can be changed on the PARAMETERS page.

5. Key PARAMETERS on TEM BRIGHT FIELD page. The PARAMETERS (1) page will be displayed.

6. Key operating ranges/conditions on the PARAMETERS (1) page. To adjust a numerical range, key as follows:

- Left-hand side for lower value
- Right-hand side for higher value

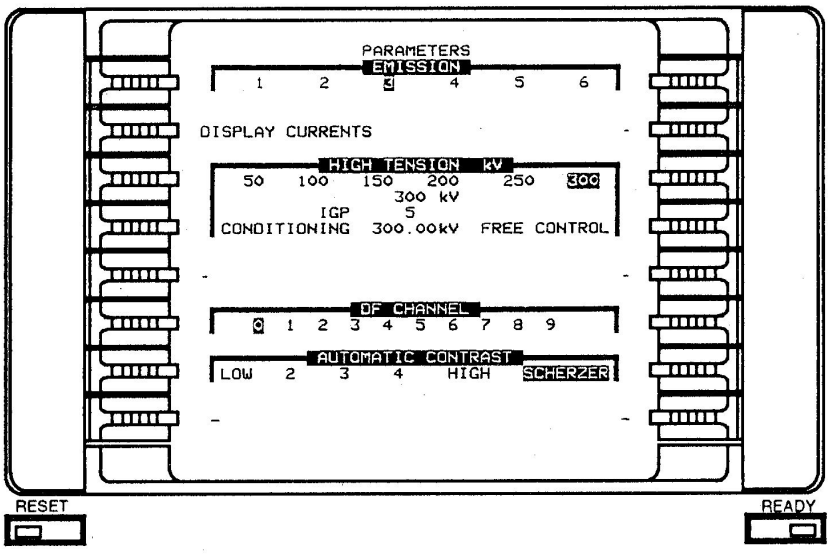


Fig. 1.7, PARAMETERS page

7. After setting the parameters press the READY key to return to the TEM BRIGHT-FIELD page.
8. Check that UHV (Ultra-High Vacuum) indicator is illuminated (if not, wait until it is). Press the HIGH

TENSION ON/OFF button. The HIGH TENSION indicator will illuminate indicating that the high voltage is switched on.

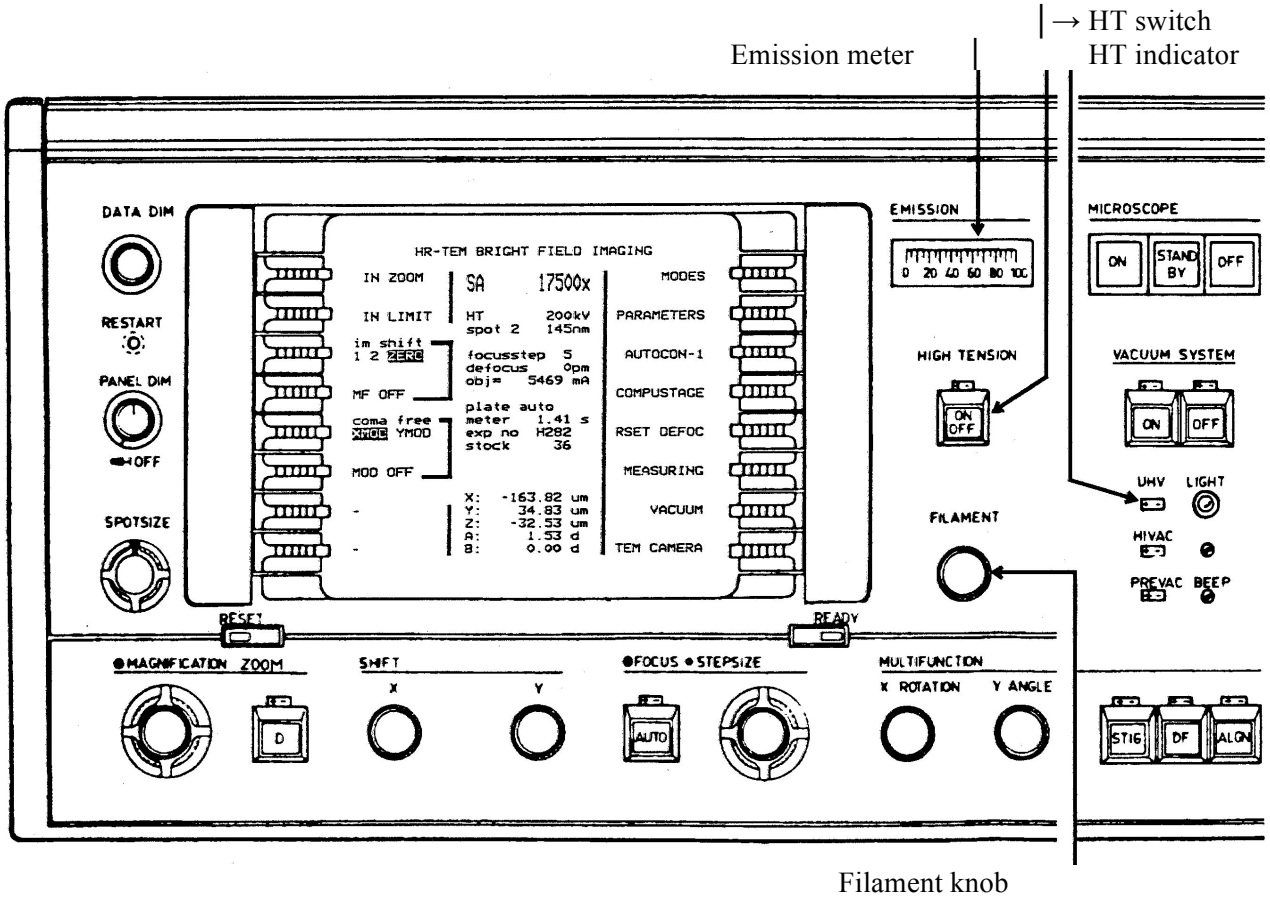


Fig. 1.8, Right-hand control panel (part)

9. Turn the FILAMENT knob clockwise to heat up the filament, while observing the EMISSION current meter until the saturation condition is obtained.
The Microcontroller will emit the BEEP signal when the filament heating has reached the FILAMENT LIMIT, which is preset on the CONFIGURATION image.

Note: The MICROCONTROLLER will increase the filament current at a rate, which ensures a smooth warming-up of the filament. The delay time per FILAMENT step is 0.1 s with TUNGSTEN and 5 s with LaB_6. If LaB_6 is selected on the CONFIGURATION page, the MICROCONTROLLER will run the filament more slowly to the desired value. This is to safeguard LaB6 filaments against thermal stress. The FILAMIENT knob may be turned more quickly, since the MICROCONTROLLER memorizes the numbers of steps selected. (For further information, see Sect. 2.4) .

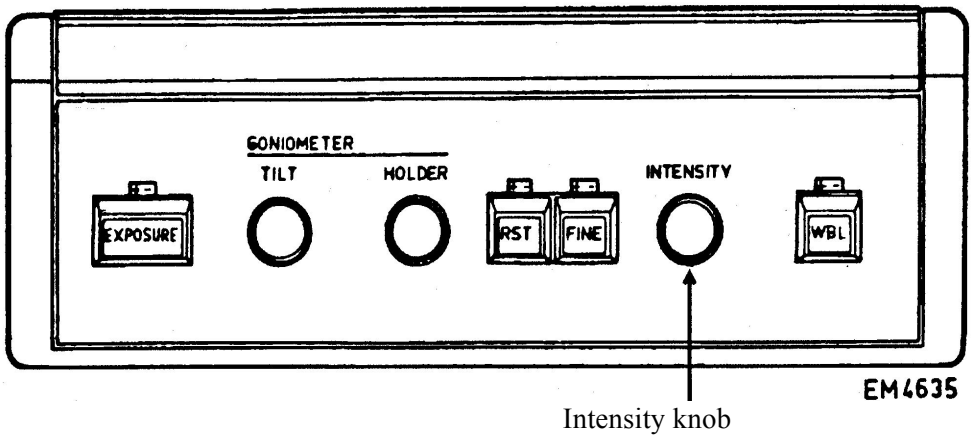
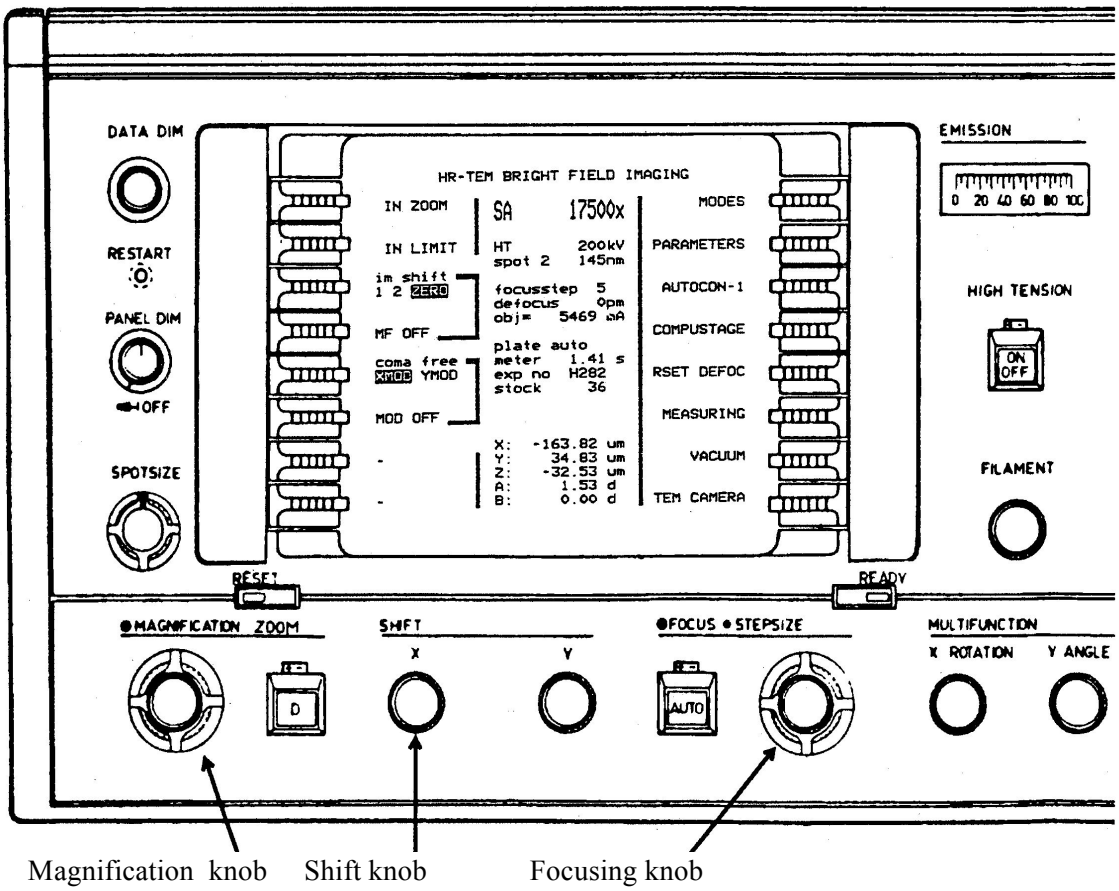


Fig 1-9 Left-hand control panel

10. Use the INTENSITY and SHIFT knobs to adjust the illumination



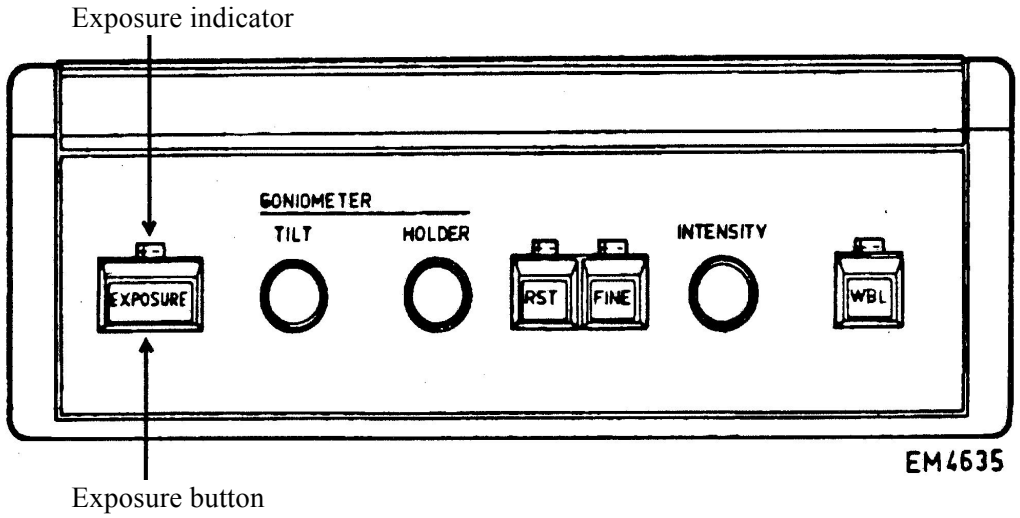
and the MAGNIFACATION and FOCUSING knobs to adjust the image as required. To insert a specimen see Chapter 6.

11. Raise the main projection screen or bring the 35 mm camera into position. The EXPOSURE indicator will light up to indicate that everything is ready to take a micrograph. However, the system will recognize when the illumination condition is not suitable:

- The meter indication on the information display will read XXX.

When there is no recording material available for the camera selected:

- The stock indication on the information display will read 00.



12. Press the EXPOSURE button:

- The EXPOSURE indicator is extinguished.
- The exposure is made
- The EXPOSURE indicator illuminates.

13. Lower the main projection screen or remove 35mm camera from the beam.

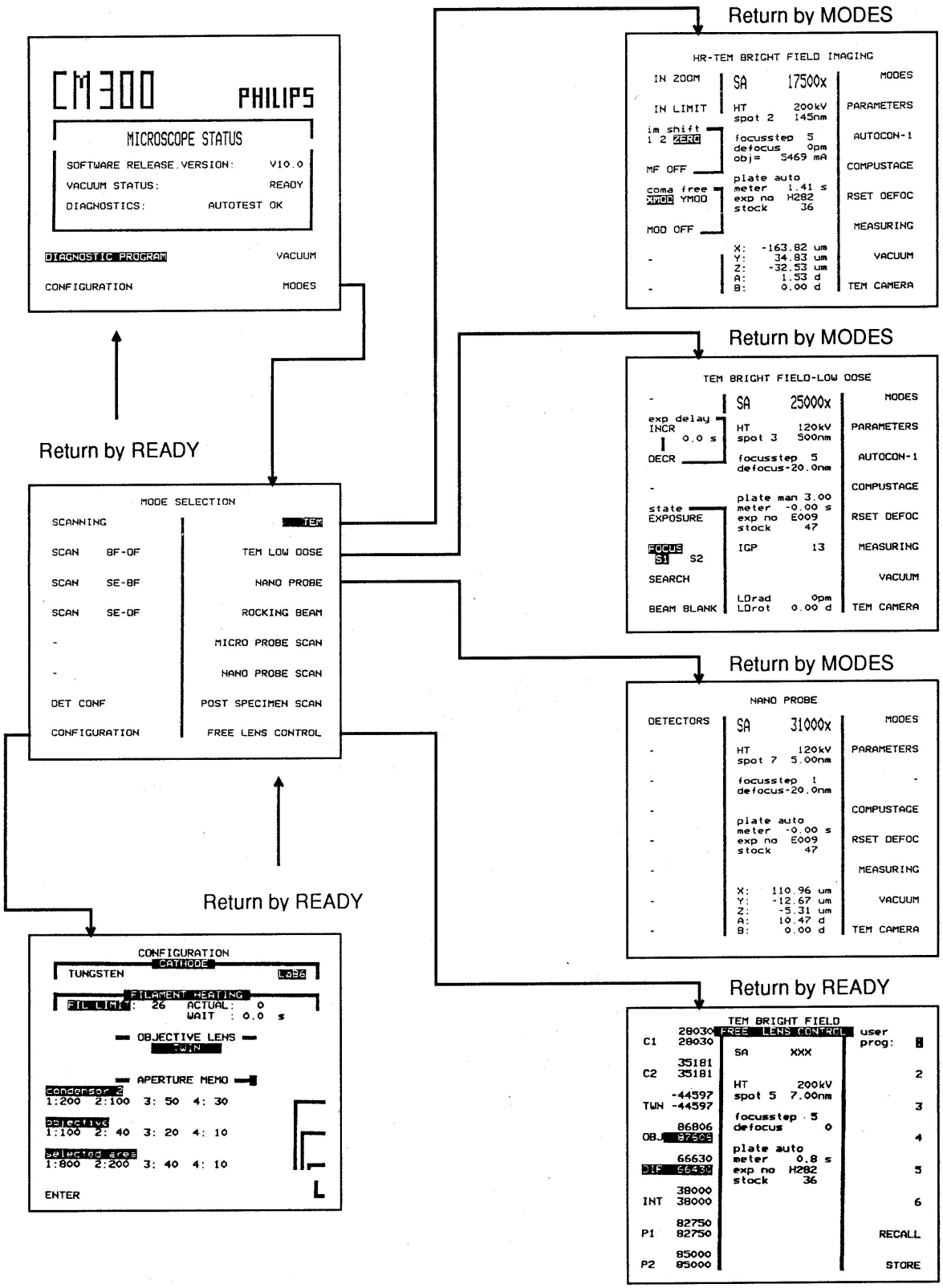
14. For more information about system status or to change parameter settings, key PARAMETERS.

15. Press the READY key to return from the PARAMETERS page to the TEM BRIGHT FIELD page.

When a specimen image has been obtained in the TEM Bright Field mode, it is then easy to obtain and optimize other types of images. The following section describes the procedure for the other common mode of operation available on the standard STEM instrument.

2 CM300 MICROSCOPE OPERATION – THE TEM MODES

2.1 MODE SELECTION



Mode page selection overview – TEM modes Fig. 2.1a

2.2 TEM OPERATIONAL MODES - OVERVIEW OF THE AVAILABLE PROCEDURES

The MODE SELECTION page gives access to the different operational modes available. Fig. 2.1 shows an overview of all possible page relations from the MODE SELECTION for a CM3OO microscope that has been configured for all available functions. Underneath each page is an indication of how to return to the MODE SELECTION page.

The sections referred to in parentheses describe the operational procedures.

Bright Field Imaging

- TEM imaging of the specimen with the Objective lens as the first magnifying lens (high magnification) indicated by M or SA on the control screen display.
- TEM imaging of the specimen with the Diffraction lens used as an objective lens (low magnification) indicated by LM on the readout.

Bright Field Diffraction

- TEM imaging of the diffraction pattern formed by the Objective lens in the M-SA mode (standard diffraction mode).
- Low-angle diffraction.

Dark field Imaging

- The illuminating beam in M-SA or LM is set at an angle to the microscope axis. The angular deviation can be set in x, y or in azimuth and tilt.

Low Dose

- For beam-sensitive specimens, a photographic exposure can be carried out with exposure conditions, area of the specimen selected and magnification setting different from those used for the initial adjustments.

Nanoprobe

- M-SA imaging by a symmetric Condenser-objective lens with the possibility to form very small spots (mini-condenser lens switched off).

2.2.1 TEM Bright field imaging

The TEM BRIGHT FIELD mode is the basic imaging mode. It has already been discussed as an extended operational example in Sect. 1.2

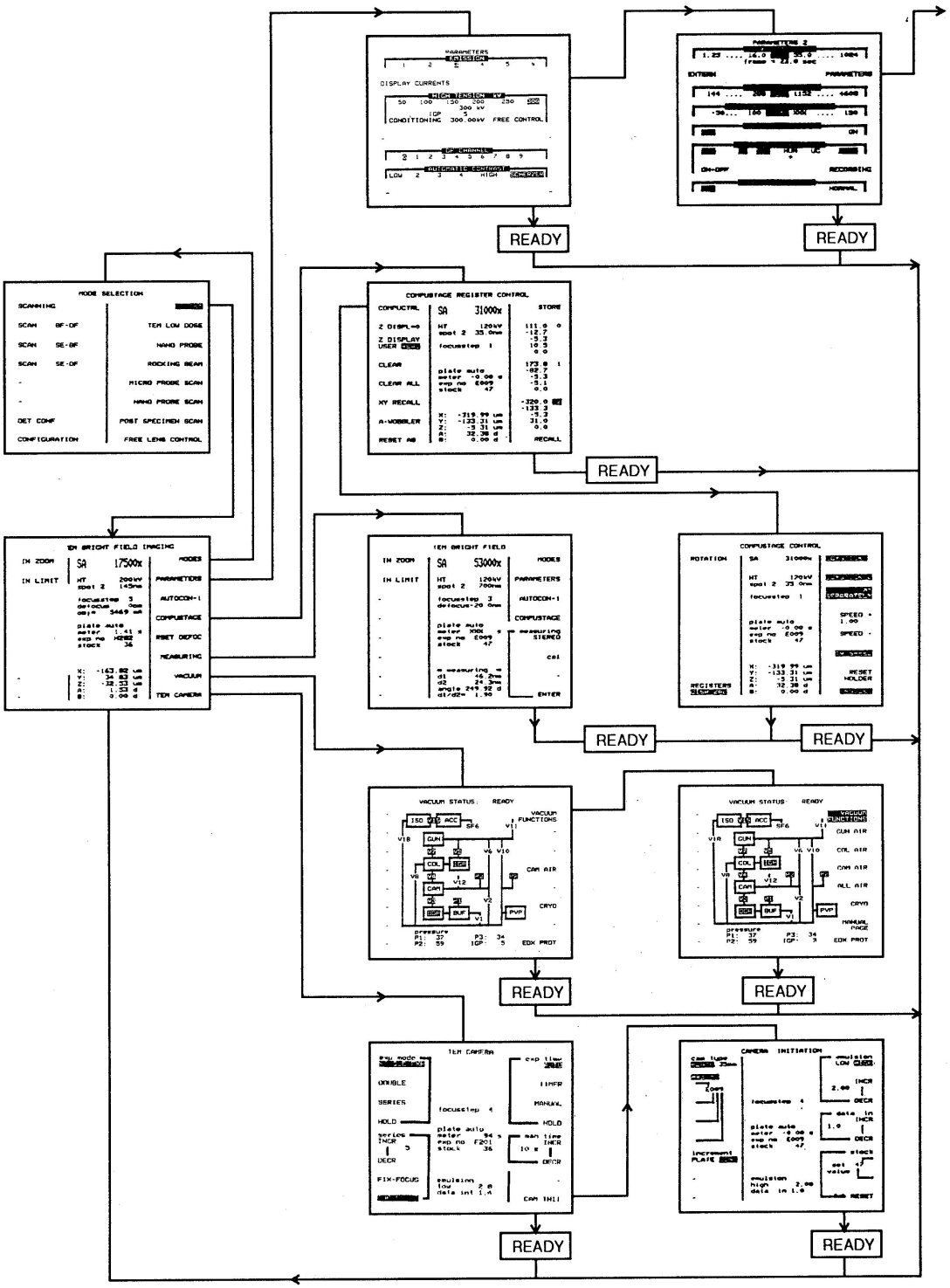
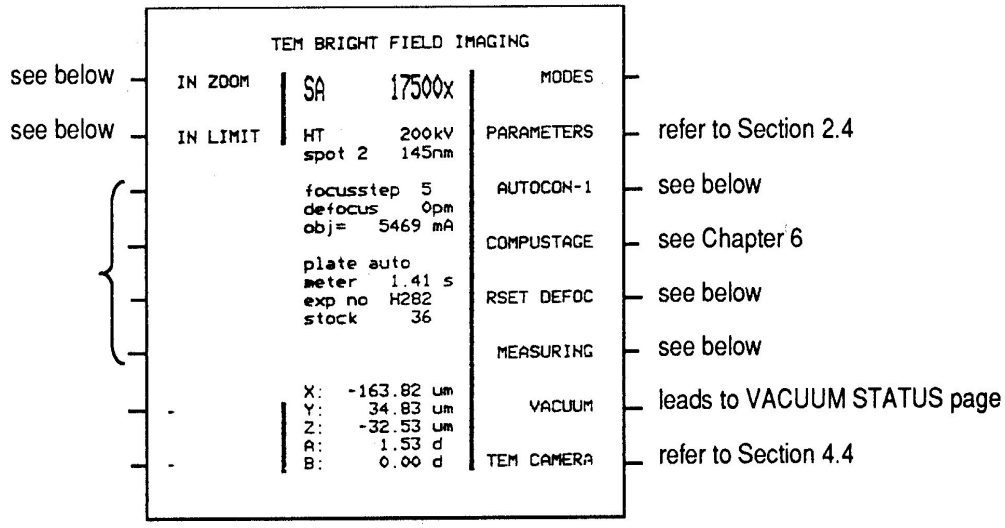


Fig 2.1b, Overview of the TEM Bright Field page showing the other pages which can be selected

Note: In this case the CM300 incorporates the 2D & 5D recall function (optional) which allows storage and recall of five coordinates X, Y, Z, α, β.

On entry the Microcontroller displays the following page:



Softkeys

INT ZOOM

Function: When highlighted, the image brightness on the screen is kept constant during magnification change. However, when going to very high magnification, the screen brightness will start to dim when the fully focused illumination condition is reached.

Operation: After the screen brightness is set to the desired level by using the INTENSITY and SPOT SIZE controls, press INT ZOOM.

INT LIMIT

Function: Protects a beam-sensitive specimen from an excessively high current density.

Operation: Overfocus the INTENSITY (turn clockwise) and then go towards focused illumination. When the required maximum current density is reached, key INT LIMIT. As long as it is active, focusing of the illumination further than this preset limit will be prevented.

AUTOCON-1...5/SCHERZER

Function : If activated, automatically applies a preselected amount of under focus for contrast control.

Operation : Focus the image (using the wobbler focusing aid, if desired) to minimum contrast. Then key AUTOCON/SCHERZER to activate the underfocus. On the first PARAMETER page, one of the six available automatic contrast settings can be chosen.

Caution! The AUTOCON/SCHERZER defocus is automatically suspended if the WoBbLer is pressed. This allows checking and readjusting of the focus while AUTOCON/SCHERZER is selected. When AUTOCON/SCHERZER is highlighted and refocusing has been carried out, the amount of defocus displayed in the information field is incorrect.

CompuStage

Function: Leads to CompuStage Register Control page if 2D & 5D recall function is incorporated. Access to storage/recall of positions and a-wobbler. If no 2D & 5D recall function is installed, this softkey leads to the CompuStage page with access to the a- wobbler and to all other functions for controlling the CompuStage, such as speed and rotation correction.

Operation: Key CompuStage.

RSET DEFOC

Function: Resets the defocus readout on the page to 0 pm. This does not change any lens currents.

Operation: Key RSET DEFOC.

Note: Defocus is automatically set to 0 pm if the wobbler is used for focusing.

AUTOCON-1..5/SCHERZER

Function: If activated, automatically applies a preselected amount of underfocus for contrast control.

Operation: Focus the image (using the wobbler focusing aid, if desired) to minimum contrast. Then key AUTOCON/SCHERZER to activate the underfocus. On the first PARAMETER page, one of the six available automatic contrast settings can be chosen.

Caution! The AUTOCON/SCHERZER defocus is automatically suspended if the WoBbLer pushbutton is pressed. This allows checking and readjusting of the focus while AUTOCON/SCHERZER is selected. When AUTOCON/SCHERZER is highlighted and refocusing has been carried out, the amount of defocus displayed in the information field is incorrect.

CompuStage

Function: Leads to CompuStage Register Control page if 2D & 5D recall function is incorporated. Access to storage/recall if positions and a-wobbler. If no 2D & 5D recall function is installed, this softkey leads to the CompuStage page with access to the a- wobbler and to all other functions for controlling the CompuStage, such as speed and rotation correction.

Operation: Key CompuStage.

RSET DEFOC

Function: Resets the defocus readout on the page to 0 pm. This does not change any lens currents.

Operation: Key RSET DEFOC.

Note: Defocus is automatically set to 0 pm if the wobbler is used for focusing.

MEASURING

Function: On-line image measurement of distances and angles between image points, or of specimen thickness.

2.2.2 TEM Bright field diffraction

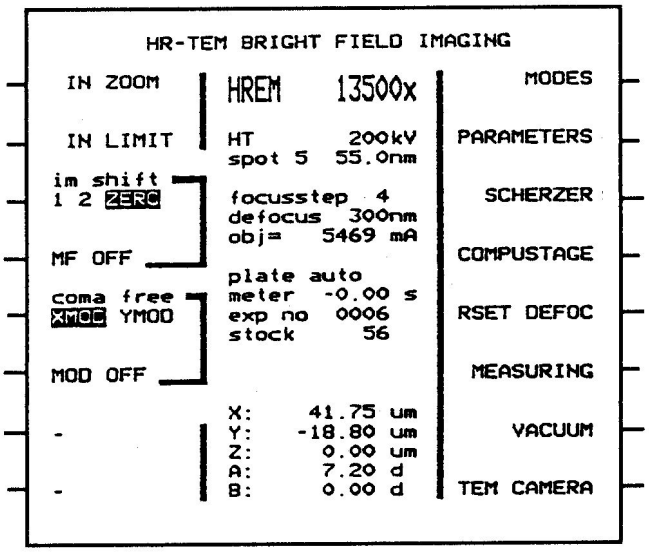
The TEM BRIGHT FIELD DIFFRACTION mode is obtained by activating the D pushbutton (LED on). Depending on the magnification range in which the image was viewed, two different types of diffraction pattern are obtained:

1. Activating the D pushbutton while in the LM range will lead to the Low Angle Diffraction (LAD) condition in which the objective aperture selects the distracting specimen area. **Before leaving the LAD mode, press the AuTofocus button** in order to set the objective lens current to a fixed value, which is optimum for LM-TEM imaging.

2. Activating the D pushbutton while at a higher magnification will project the diffraction pattern formed at the back-focal plane of the objective lens onto the viewing screen. The area selection can be carried out by restricting the illumination to the desired area, or by using the selected area (SA) aperture. With fully focused illumination, a convergent- beam diffraction pattern is obtained.

Method 2 is the standard diffraction ray path.

In the TEM BRIGHT FIELD DIFFRACTION mode, the Microcontroller will display the following Page:



Softkeys

MEASURING

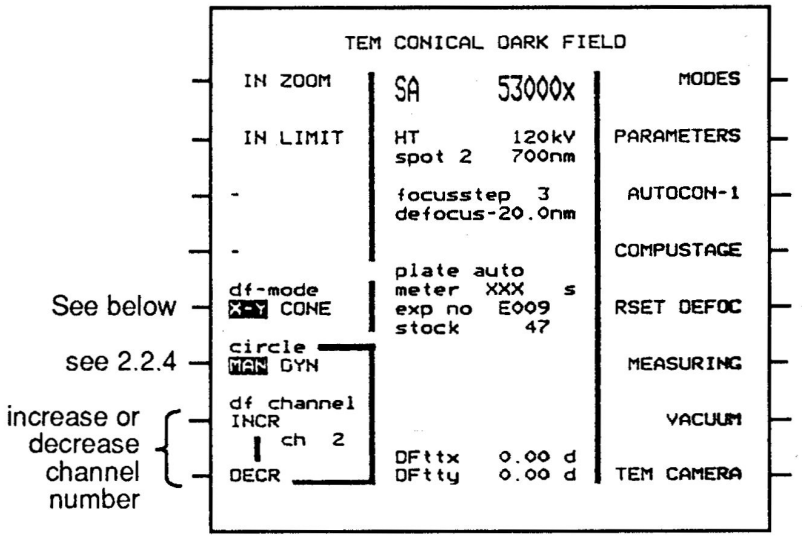
Function: Allows measurement of d-spacings and interplaner angles in the diffraction pattern.

Operation: Refer to Sect. 2.3.7.

2.2.3 TEM Dark field imaging

The TEM DARK FIELD mode allows images and diffraction patterns to be obtained with tilted illumination so that the diffracted beam(s) pass along the optical axis of the microscope. This mode can be activated from the TEM BRIGHT FIELD imaging or diffraction modes by pressing the DF button. Once the DF mode has been selected, the MULTIFUNCTION knobs take over control of beam tilt, while the SHIFT knobs continue to control illumination shift: this shift is an additional shift which is only added in Dark Field mode.
There are a total of 20 Dark Field channels available for storing Dark Field settings (both beam tilt and shift). 10 are present in the high magnification range and 10 in the low. These channels can be selected on the first PARAMETER page (see Sect. 2.2.6) or directly when working in "circle man" with INCR to increase the channel number or DECR to decrease it.

In the TEM DARK FIELD imaging mode, the Microcontroller will display the following page:



Softkeys

df-mode X-Y/CONE

Function: The beam can be tilted in either:
- Two perpendicular directions (X-Y).
- A conical (CONE) configuration (ROTATION and ANGLE).

Operation: Press the key to toggle between X-Y and CONE.

Information field

The standard information field content is extended with the readout of the beam tilt according to the tilt mode selected. The X-Y tilt and the azimuth angle are measured with respect to the optical axis (Bright Field illumination axis). The Rotation is measured with respect to an arbitrary direction in the specimen plane.

RESET

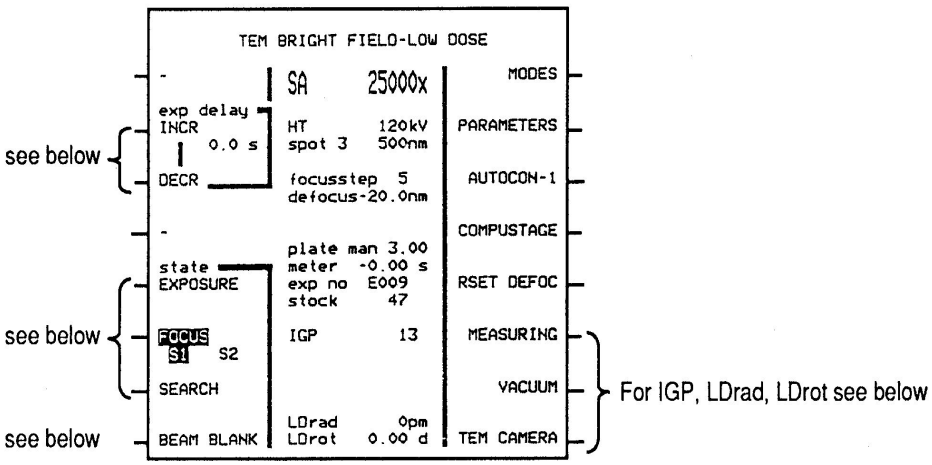
Pressing the RESET button sets the Dark Field tilt (DFttx, DFtty, DFtlt and DFrot) and the additional Dark Field shift values in the active Dark Field channel back to zero.

Note: 1) Ten Dark Field channels exist. These are described in Sect. 2.2.6.
2) The objective stigmator settings in channels 1 and 2 are identical to those in the Bright Field mode and can be adjusted freely in both modes.

2.2.7 TEM LOW-DOSE mode

Usage: The TEM LOW-DOSE mode is used for photographing undamaged areas of beam- sensitive specimens. It gives the possibility to set up the instrument and get it ready for recording while illuminating and viewing a specimen area remote from where the micrograph is to be taken. For ultimate specimen protection, one can activate a beam blanker whenever not actually watching an image.

On entering the LOW-DOSE mode, the Microcontroller will display a page similar to the one below (the settings may be different as they depend on the conditions at the time of leaving the LOW DOSE mode):



Softkeys

exp delay

INCR
DECR

Function: Defines the delay time between decentering of the beam and image deflection and the subsequent opening of the exposure shutter for pre-irradiation of the specimen area to be photographed. As this represents an additional irradiation, the time should be kept to a minimum, preferably zero. This allows the introduction of a specimen settling time (for photographic exposure times of 0.2 sec or longer).

Operation: Select the desired time by increasing (INCR) or decreasing (DECR) the displayed value.

state
EXPOSURE

Function: The EXPOSURE state is selected to set up the exposure conditions for photography (magnification and illumination: spotsize, intensity and beam shift).

Operation: Highlight the exposure label by keying EXPOSURE and adjust the parameters as desired for the photographic exposure.

FOCUS
S1 52

Function: The FOCUS state is selected to carry out focusing and astigmatism corrections on areas of the specimen adjacent to the area selected for photography. The focus and stigmatic settings will be taken over the image recorded under the exposure conditions selected in the EXPOSURE state. The two substages S1 and 52 can be assigned different image shifts and beam shifts.

Operation: Press softkey to select FOCUS state S1 or S2. Set image shift in S1 (and in S2 if desired).

Select magnification and illumination suitable for optimizing the image. Focus image and correct astigmatism.

SEARCH

Function: The SEARCH stale allows search conditions to be set with magnification and illumination independent of the EXPOSURE and FOCUS states.

Operation: Generally, a lower magnification and/or dimmer illumination than in the other states will be used to minimize damage and allow a good overview of specimen areas of interest.

BEAM BLANK

Function: The beam blanker deflects the beam away from the specimen to allow absolute specimen protection whenever illumination is not needed.

Operation: Press softkey to activate (text highlighted) or deactivate.

Caution! The beam blanker will be deactivated when an exposure is made from the FOCUS state, but not when an exposure is started from SEARCH or EXPOSURE states.

Information field

IGP:
Presents the Ion-Getter Pump readout (from VACUUM page) as an extra check on vacuum conditions during CRYO work.

LDrad (in FOCUS S1 or S2):
Represents a linear image shift, controlled by the MF-Y knob. Movement is parallel to the specimen tilt axis when LDrot = 0 or 180 deg. Independent for S1 and S2.

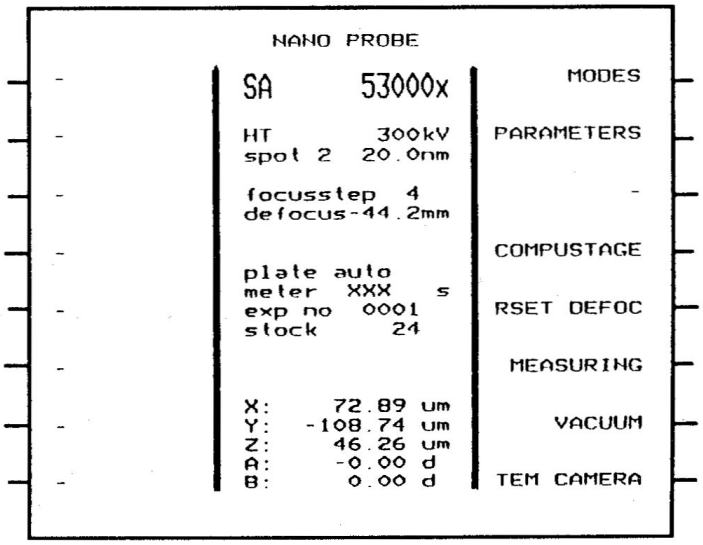
LDrot (in FOCUS S1 or S2):
Represents a rotational image shift, controlled by the MF-X knob, in conjunction with LDrot. Independent for S1 and S2.

2.2.10 Nanoprobe mode

In the NANOPROBE mode the Objective lens is operated in the Condenser-objective mode. This allows much smaller probes to be achieved than can be obtained in the MICROPROBE (TEM) mode. The NANOPROBE mode can also be used for high-resolution TEM imaging of small areas because, with defocused, parallel illumination the area illuminated by the beam is much smaller giving higher image brightness.
The interrelationships between the NANOPROBE and MICROPROBE modes vary with respect to the following parameters:

- The Objective-stigmator setting is defined in the MICROPROBE mode (TEM).
- Objective-lens current and Condenser Stigmator are controlled independently of optical mode selected.
- Magnification is changed for both modes simultaneously, irrespective of the mode selected at the time.

NANOPROBE mode, the Microcontroller will display the following page:



Softkeys

All softkeys operate as in the TEM (microprobe) mode. Refer to Sect. 2.2.1, TEM bright field imaging and 2.2.2, DIFFRACTION modes.

Information field

The NANOPROBE mode has its own set of spot size values related to the spot size number.

Nanoprobe spot sizes

The effective spot size in NANOPROBE mode is, to a large extent, defined by two parameters:

1. The geometric demagnification of the beam diameter at the level of the electron gun (Dgeom), which can be varied by the Spot Size.
2. The influence of the spherical aberration of the final lens (Dcs), which is dependent on the Condenser 2 aperture selected.

The two parameters can be related to the effective spot size (Deff) as follows:

$$D_{eff} = \sqrt{(D_{geom})^2 + (D_{cs})^2}$$

Dcs values are listed in Table 2.2 for a range of Condenser 2 aperture sizes enabling other values of effective spot size to be calculated.

Spot size selector	Dgeom (nm)		Advised C2 apert. (μm)		Deff nanoprobe (nm)	
	T	ST	T	ST	T	ST
1	40	301	100	90	65	48
2	30	22	90	80	48	34
3	25	18	80	70	36	25
4	19	14	70	60	25	18
5	14	10	60	60	18	15
6	11	8	60	50	16	10
7	7.5	5.5	50	40	10	6.4
8	4.7	3.5	40	40	5.7	4.8
9	3	2.2	30	30	3.3	2.6
10	2	1.6	30	20	2.4	1.65
11	1.5	1.1	30	20	2.0	1.2

Table 2.1, Range off effective spot size for the TWIN (T) and SuperTWIN (ST) objective lenses in the nanoprobe mode for selected Condenser 2 apertures (standard tungsten filament) in eucentric goniometer height position.

C2 aperture (μm)	Dcs TWIN (nm)	Dcs SuperTWIN (nm)
5	0.006	0.015
10	0.05	0.12
15	0.17	0.41
20	0.40	0.98
30	1.4	3.3
40	3.3	7.8
50	6.4	15.3
60	11	26
70	17	42
80	26	63
90	37	89
100	51	122
150	171	412
200	406	977

Table 2.2, Spherical aberration values in the nanoprobe mode for a range of condenser 2 apertures.

Note: 1) When a LaB_6 filament is used, geometric spot sizes will be 2 - 4 times smaller, depending on the make of filament. 2) Spot size is defined as the full-width at half-maximum value of the electron density distribution.