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I

I STEREOSCAN 200

SCANNING ELECTRON MICROSCOPE

I OP£RATil\C INSTRUCTIONS

TL 2025-0M

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Cambr idge Instrumen ts Ltd Rustat Road

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Cambr idge

CBl 3QH

England

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Th is publication summar ises the recommended proced ures for oper ating the descr ibed instrument. It supplements, but does not replace, the contents of an **approved operator's training course. Ne w users are strongly adv ised to parti cipate in such a course before operating their instruments. Details of courses and enrolment procedures are available from accredi ted Cambridge** distributors and service organisa tions and f rom Cambridge Instr uments Ltd, Sales Department, Rust at Road, Cambridge, CBl 3QH, England.

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The information in this publication is believed to be correct and complete, but should any user identif y an apparent error or omission, deta ils will be welcomed by the Technical Publicat ions Depart ment, at the above address. Due to a cont inuous d evelopment programme, Cambr idge Instruments Ltd reserve the

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I 2

WARNINGS RE USE OF 5200

I

1. EHT VOLTAGES JN THIS INSTRUMENT ARE LETHAL

In terlock ing saf ety clrcui ts are incorporated both to sa feguard the **equi pment during certain operat ing condi t i ons, and to safeguard personnel dur ing mai ntenance procedures on, for i nstance, the electron opt ical**

I

column. In addit ion WA RNING not ices are aff ixed at danger po ints. An y

I

attempts to overr ide these saf ety circu i ts will invol ve r isk of contact with voltages of up to 30 KV.

**Do not remove the cover from any electronic uni t to gain access while the**

I

equipment is operat ing.

1. LINE VOLTAGE

I **L ine voltage is present at var ious places in the instrument when connected**

to the electr ical supply, even with the instrument power switch in t he OFF

**posi t ion.**

I

ALWAYS ISOLATE **TI-E** INSTRUMENT FROM Tl-£ POWER BEFORE ATTEMPTING ANY MAINTENANCE WORK.

I 3. X-RAD!ATION

The i nstr u ment is designed to ensure tha t X-radi a t ion is less than that **permi tted under any international or federal legislat ion. To achieve this, appropriate ma ter ia ls are used throughout, and radiat i on shi elds are f i t ted.**

I

Customers are adv ised to check X-radi ation levels when inst alling thei r **own exper i mental equipment, or when f i tt ing accessories not supplied by** Cambridge Instrumen ts Ltd.

I

I 4. TRANSIT CLAMPS

To avoid da mage to the equ ipment during transi t, the gun, specimen stage,

suspension system and the turbomolecular pump are fitted wi th transi t

I

**clamps whi ch must be removed duri ng the installat ion procedure (see**

Chapter 6).

5. ROTARY PUMP EXHAUST

I

The discharge from the rotary pump will conta in a small quant i t y of oil m ist and this can contami na te the environment and create a health hazard

I

when used in enclosed surround ings. To avoid this risk an exhaust system should be provid ed, as described in the Installat ion Recommendations.

I 6.

I I

SOLVENTS

Careless use of solven ts (Arklone, Propanol, Methanol etc) can consti t u te a health hazard. Use m i n ima l quan t i t ies and take all possi ble precautions to avoid spill age, skin and eye contact, and vapour inhalation. Before using any solvent be familiar wi th the published saf ety procedures (normally provided by the solven t manufacturers) and comply with them.

###### I

3

I 7. CORROSION

Althoug h all components used in the 5200 are protected from corrosion

either by plating, painting or other anti-corrosion treatmen t, Cambridge Instruments ltd accept no responsibility for corrosi on caused by storing the **5200 in adverse atmospheric condi ti ons.**

I

1. FANS

I

The instrumen t is totall y a i r cooled and the inpu t to, and the outlets from, the cooling fans should not be blocked or impa ired. The removal of any of

I

the instrumen ts covers will upset the air flow and the instr ument should not be run with any covers removed. Keep the fingers well away from the

fans at all t imes.

I 9.

**WARN** ALL

.

USERS

It should be a mat ter of rout ine to bring these warn ings to the noti ce of ALL and EVERY user. A user who in i t ia lly comes for only five m inutes **may, and often does, f ind hi msel f usi ng the microscope unsuperv ised, even** though th is was def in itely never intended to happen.

I

I

IF IN DOU3T CON:!ULT AN AUTHORISED SAFETY OFFICER

I

I

I I I

I I

I

I 4

I 5200 OPERATORS MANUAL

I Contents

I Chapter 1

Chapter 2

I Chapter 3

Chapter 4

I Chapter 5

Chapter 6

I Chapter 7

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Operati ng rout ines

The Control Console - Wha t the Controls Do

Maintenance

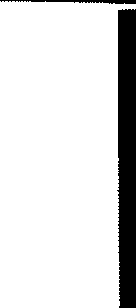
Opt ions

Advanced Operat ing Installation

The Scanning Electron Microscope



I



I 5

I **CHAPTER 1 OPERA TING ROUTINES**

These instruct ions provide a simple gu ide to some frequentl y used operat ing

routines. Before using these routines a ll operat ors should be f amiliar wi th

I

chapter 2 of this manual , usi ng this section only as a remi nder of the sequence of

**operations.**

When followi ng these rout ines there may be a choice of paths. The operator must consider the relevant f acts and choose the r ight path.

I

**Note A** Follow the rou tine caref ull y, one step at a time.

I **Note B** The 5200 should always be lef t in an evacuated state when not in use.

The rout ines covered by this chapter are as follows:-

I

Rout ine 1 Switching on and get t ing a work ing vacuum

Rout ine lA Switching on and get ting a work ing vacuum (ion pump) Rout ine 2 Obta ining a picture

I

I Rout ine 3 Tak ing a Micrograph

Routine 4 Changing the Specimen

I Rout ine 5 Switching off

Rout ine 6 Filament Change

I Routine 7 Changing the Accelera tion Volt age Range

I

I

I

I 6

I ROUTINE 1

SWITCHING ON AND GETTING A WORKING VACUUM

Turn on external power to the 5200

I

I

Iorn -pu-m p option fitted 1

YM

I I

I

Check CHAMBER Vacuum not selected Go to rout ine lA

I

Press green ON switch

l

I

Open specimen stage

I

Check suitable specimens installed

I

I

Close specimen stage

I

Press CHA MBER Vacuu m bu tton to on

I

I

Wa i t a f ew m inutes

I

I

V acuum ready? (Swi tch illuminated)

Yes No

WIait

I

I

5 mi.nutes

Vacuum ready?

I

Yes No

I

Vacuum leak, (stage '0' ring) hea vy outgassing,

I

I Go to rou tine 2

I

I

vacuum system f ailure. Consu lt operators manual

CH3.

7

**ROUTINE lA**

I

**SWITCHING ON AND GETTING A WORKING VACWM WITH ION PUMP**

I Turn on external power to the 5200

I

Check CHAMBER Vacuum not selected

I

Check COLUMN V acuum not selected

I

I

Press green ON switch

I

Open specimen stage

I

I

Check suitable specimens installed

I

Close specimen stage

I

I

Select CHA MBER Vacuum

I

Select COLUMN Vacuum

I

I

**\A/ait a few minutes**

I

CHA MBER Vacuu m ready? (Switch il luminated)

I

Yes

I I

No

I

Wa it 5 m inutes

I

Vacuum ready?

Yes No

[

Vacuum leak (stage '0' r ing), heavy outgassing,

**vacuum system failure. Consult opera tors manual**

I

CH3.

Wa it 10-20 mi nu tes

I

I

COLUMN Vacuu m ready (swi tch illumina ted)

Yes

I

No

I

Wa it 5 m inu tes

t

Vacuum ready?

Yes No

I

**Vacuum**

fa ilure.

leak, heavy outgassi ng or vacuum system Consult operators manual chapter 3.

Go to routine 2

I 8

I **ROUTINE 2**

**OBTAINING A PICTURE**

I **V acuum ready?**

Yes

I l

No

I

Go to rout ine 1

Select the following:- MAGNIFICATION Coarse, Visual Sri cen tred, SIGNAL

LEVEL Au to, Auto Level centred, Contrast between 1st and 2nd mark, SCANNING MODE TV, STIGMATOR X and Y centred, FOCUS Coarse lOmm, EMITTER

not La86, OPTIBEAM Norma l, RESOLUTION Coarse 6, RESOLUTION Fine clockwise, ACCELER ATION VOL TAGE 25, High, Fine clockwise, Filamen t minimum BE AM o ff , INPUT SELECT S.E., SIGNAL not INVER Ted, SPLIT

I

SCREEN of f , GAMMA ant iclockwise, DIFF ant iclockwise, SCAN Nor ma l, FOCUS MOO Off , EMISSION IMAGE of f, all four GUN ALIGNMENT controls centred. Check tha t all opt ions are selected OFF or NORMAL. The setting of any other con trols is irrelevant.

I

I

Turn OPER ATE on

I

Wa it 30 seconds

**l**

I

R aster v isi ble?

Yes No

I

I Increase Visual Sri

Check setting of all controls

Are all opt ions switched to nor mal?

Start again

I La86 opt ion fitted

I I

No Yes

I LJect EMITTER La86

Switch BE AM on

I

**l**

Lab6 option fitted

No

T

I

I

rn.mooc '" """·m..,..

Yes

I

Slowly increase

Filament to cen tre marker.

**Watch vacuum meter**

for signs of outgassi ng.

I

Spin M AGNIFICATION Change Oigiknob ant iclockwise

I

**l**

**Image of specimen visible?**

I

I 9

Yes No

I

I

Filament Fail lamp on?

Yes

I

1

Change

No

I

Beam tripped lamp on?

I Filament

I I

I Switch E MISS!ON IMAGE on

l

Set RESOLUT!ON to 2 or 3

I

Yes

l

Reset

Beam

t

Trip

again? Clean gun

I

No

I

Gun alignment controls

cent red

I

**Final aperture centred**

(Set micrometers to

Y=6, X=6)

Cent re br ight source on CRT usi ng X and Y Shif t

I

I

Reduce A uto Level so det a il is v isible i n emission i mage

I -

Adjust FIL A MENT current to 1st or Znd peak as requ ired (sect ion 2.6.4)

I

I

Set RESOLUTION to 6 or 7

I

Cent re brightest part of source in the emission image usi ng X and Y Til t

I

I

Switch EMISSION !MAGE off

I

Using FOCUS COA RSE obta in a sharp image

I

l

Using specimen stage con t rols select a suitable specimen area

l

lncrease MAGNIFICA T!ON

I

j

Adjust as necessary to obt ain the requi red image:

FOCUS (Coarse at very low ma g, Med ium and Fine at hi gher mags) MAG N!FICATION

I

I

RESOLUTION (turn clockwise to increase resol ution at the expense of image noise)

SCANNING MODE (slower scan speeds reduce image noise) Stage movements

STIGMA TORS

IMAGE SHIFT to give fine image movement at high magni f ication

I

I

I 10

ROUTINE 3

I

TAKING A MICROGRAPH

I Suitable ima-ge-o-n ,display?

Yes No

I I T!y rout ine Z

Check correct camera and film fitted

I

I

Select photo scan time (FAST is 50 seconds, SLOW is 200 seconds)

I

Check Photo number and Specimen nu mber in data zone are correctly set

I

I

First photo of session

No Yes

I

I

Select Graph on SCAN swi tch

I

Set Con trast and Auto Level so graph

nearl y spans markers on displa y

I

Note settings on Con trast and Auto level

I

I

Select Normal on SCAN switch

Open camera shu tter (if i t has one)

I

I

Press PHOTO START

l

When photo scan stops (scann ing returns to visua l mode) develop picture

(Polaroid) or wind on film (roll film cameras)

l

Photo exposure correct

I !-- ·------..

Yes

I

No

I

Data zone exposure correct

Yes No

I

Reset graph and try aga in

I

I

Check camera aperture and f ilm type

I

R eset PHOTO BR!

and CONT. See section 2.8.4

Now look for another suitable area of specimen

I

I 11

I **ROUTINE 4**

**CHANGING Tf-E SPEClf\llEN**

I This routine can be used at any t ime provided power is switched ON Select BEAM of f

I

I

Release stage clamp

**l**

I Ion pump fitted

No Yes

I

I

Check gun isolat ion valve is closed

**l**

Close column isolat ion valve

I Select CHAMBER Vacuum vent

I

Remove stage from chamber

I

**l**

Change specimen (me thod depends on stage and holders in use)

**l**

Ref i t stage to chamber

I

**l**

Select CHAMBER Vacuum

**1**

I

Wai t 2 m inutes

I

Vacuum ready?

Yes

**l**

Ion pu m p fitted

I

No

**l**

R emove stage and clean

**stage closure 101 ring**

No Yes

I

I- ------oh·en column isolation val ve

I Select BE A M on

I!age visi b le?

Yes

I

I

Cont inue

No

**1**

Try rou t ine 2

I

···-------- --- - ------------ -

#### I

I 12

I **ROUTINE 5**

**SWITCHING OFF**

Select BE A M of f

I

I

The S200 may now saf ely overnigh t closedown:

I

Swi tch OPERATE off

be lef t for per iods of several hours. For an

I The S200 may now saf ely be lef t for per iods of several days. It is strongly

recommended that the 5200 is lef t under vacuum whenever possi ble. If i t

is absolutely necessary to switch the S200 off completel y: Switch power OFF

I

I

WITH POWE R OFF THE COLUMN IS VENTED (if the opt ional baf fle val ve is not fitted). IF LEFT IN THIS STATE FOR LONG PE RIODS JN A N ADVERSE ATMOSPHERE THE COLUMN MA Y CORRODE. IF IT IS NECESSA R Y TO LEAVE THE 5200 IN THIS STATE FOR LONG PERIODS IT SHOULD BE F ILLED WITH A DRY INER T GAS e.g. DR Y NITROGEN.

I

I

I I I I

**l**

I 13

I **ROUTINE** 6

CHANGING **Tl-£ FILAMENT**

I This rout ine can be used at any time provided that power is ON Select BE AM off

I

I Release stage clamp (large stage only) SeIlect CHAMBE-R Vacuum vent

I

I

lon pump fitted

No

I

I

Open the gun

I

I

Yes

I

Select COLUMN Vacuum ven t

I

Cover top of column wi th dust free paper

I

**l**

L oosen

I

the t hree fir ing unit clamp screws

**Remove f ir ing uni t from gun**

I

I

Chan ge f ilament (fu ll deta ils in section 3.3.7)

I

Fit fir ing unit to gun

I

I

T ighten the t hree f iring uni t clamp screws

I

Close gun

I

I

Select CHA MBER Vacuum

I

I Ion pump fit ted

No

I I

Wai t

I

I

**V acuurn**

**ready?**

Yes

I

Select COLUMN Vacuum

I

Yes

I l

No

I

Clean gun '0' ri ng

Select BEAM on

Ajust FIL AMENT cu rrent and a lig n gun as requ ired

I

I

I

I 14

I ROUTINE 7

CHANGING THE Aca:LERATION VOLTAGE RANGE

I

H-£ S200 SHOULD NOT BE USED ON THE HIGH KV RANGE WITH THE LOW KV ANODE FITTED

I Switch BE AM of f

I

Select the desired KV range on the ACCELER AT!ON VOLTAGE High control

I

I

Admit air to the column (Rou tine 6)

I

I

Open the gun

I

Lif t ou t the anode

I

I

Fit other anode OR fit or remove anode spacer (the low KV anode is ta ller than

the high KV one)

J

I

Close gun

I

Pump column (Rou t ine 6)

I

I Obta in an image (Rou t ine 2)

I

i I I I I

I



I

I 15

CHAPTER 2

I

Tl-£ CONTROL CONSOLE - WHAT Tl-£ CONTROLS DO

I Contents

* 1. INTRODUCTION

I 2.1 Power Switching Controls

2.1.l Power

2.1.2 Opera te

I

* 1. Electron Optics Controls
     1. Bea m

I

* + 1. Acceleration Voltage
    2. Fil!men t
    3. Resolut ion Coarse and Fine

I

* + 1. Opt ibeam Normal

Change Aperture

* + 1. Emi t ter LaB6
    2. Focus Coarse, Medi um and Fine

I

2.2.B Stigma tor

* 1. Scanning Controls
     1. Magnifica t ion Change and Coarse

I

* + 1. Scanning Mode
    2. Photo
    3. Image Shif t

I

* 1. Display Controls

2.4.l Signa l Level Auto

A uto Level Manual Level Hol d

Contrast

I

* + 1. Display Control-Visual Brigh tness
    2. Key Pad
  1. Image Processing Controls

I

* + 1. Input Select and Secondary/Reflected electron swi tch
    2. Signa l Mi x

I

* + 1. Invert
    2. Gamma
    3. Di ff
    4. Spli t Screen

I

* + 1. Zoom
    2. Scan-Normal, Graph, Line and Spot
  1. Beam Processing Controls

2.6.l Focus Modu lation-Off , Focus Wobble and Dynamic Focus

* + 1. Change
    2. Til t Correct ion
    3. Gun Alignmen t-E mission Ima ge, X-Y Til t and X-Y Shi f t
    4. Scan Rotat ion Of f /Coarse/Fine

Change

**L**

I **2.7**

I

I **Z.8**

I

I **2.9**

**2.10**

I **2.11**

16

**Vacuum Controls**

* + 1. Cham ber Vacuum
    2. Pressure
    3. ColiChamber
    4. Column Vacuum
    5. Valve Status

**Record Unit Controls and Calibration**

2.8.l Bri ghtness

2.8.2 Contrast

* + 1. Film ASA
    2. Cal ibrat ion
    3. Uncal LED **Final Aperture Centring The Data Zone**

**The Text Facility**

2. 11.1

**l**

2.11.2

2.11.3

2.ll.4

Z.11.5

I 2. 11.6

**List of niustrations**

I

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Wri ting Text Edi ting

Video mode T i tle Mode

Summary of Key Funct ions

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Figure 215

Figure 216

I

Figure 2;? Figure 2j8 Figu re Zi9 Figure 2Jl0 Figure 2J ll

I

i

I

Power Swi tching Con trols Electron Opti cs Controls Scanning Controls

Displa y Con trols

Image Processing Cont rols Beam Processing Con tro ls **Vacuum Controls**

Record Uni t Controls Fina l Aperture Changer

Setting the Filament Curren t HRR U Lens Posi t ioning

I

I 17

I 2. **INTROOUCTION**

**This secti on of the manual is wri tten as a "hands on" instruction. The**

person readi ng i t is encou r aged to sit in fron t of the 5200 and oper ate i t step by step. All control f unct ions of the 5200 are f ully protected aga inst **operator error and it is not possi ble to damage the instrument by i ncorrect** operation.

I

I

A lmost all the controls of the 5200 are situated on the console front panel. The frequently used controls are on the lower part of the panel, the less frequen t ly used controls being grouped on the upper section.

I

**There are three small groups of controls not mounted on the console front**

panel. These are:

I **the vacUum controls, mounted on the front of the plinth**

the record uni t calibr ation con trols, mounted on the desk top to the

righ t of the ma in con trol panel, behind the camera moun t ing

I

t he text keyboard. This is free stand ing and may be posi tioned anywhere on the 5200 desktop.

I There is some space lef t on the upper level of the con t rol panel for opt ion

con tro ls.

I

Some of the con trols moun t ed on the vacuu m con trol panel wi ll on ly be used when the ion pu mp option is fitted (see chapter 4).

The standard front panel controls will be considered in four groupings. These are:

I

..

l. Power Switching

* + 1. E lectron Optics Con t rol

I

* + 1. Scann ing Con trols

4. Signa l Level Controls

I The less frequen t ly used controls on the upper panel are:

5.

I 6.

Image Processi ng Con trols (the lef t hand group) Beam Processi ng Controls (the r ight hand group)

Controls not situa ted on the front panel are:

1. Vacuum Cont rols (on the front of the plinth )

I

1. R ecord Uni t Controls (to the r ight of the mai n con trol panel)
2. Fina l A perture Centring (mounted on the front of the column) 10. The Text Keyboard

I

Not really a con trol, but how you know wha t the controls are doing, is:

11. The Data Zone

**2.1 Power Switching (figure 2.1)**

Consists of two con trols grouped at the lef t hand side of the con trol

**panel. These controls are;**

------------ - - - - ---------- ---

I

I 18

**2.1.l Power** (on the upper lef t con trol panel)

I

Consists of a green ON button and a red OFF button. When the 5200 is connected to a source of mai ns power the red OFF swi tch is i llum ina ted to warn the operator that some parts of the 5200 may be live. (The only parts of the instr umen t which are powered in this condit ion are some parts of the main switch ing un it which are not accessible to the operator.) When the ON button is pressed, it wi ll illuminate and the mai n supply to the instrument is swi tched on.

I

I

When the OFF Bu tton is pressed the system will switch of f.

I

Both switches are momen tary act ing non-la tching t ypes, so they give no posi tional i nd icat ion of their status. [f both switches

I are pressed sim ul taneously, the machine will switch of f .

Power will normall y be lef t on permanen tly and these con tro'Is

wi ll only be operated when the 5200 is to be switched off for long periods. The 5200 power system is designed for continuous **running.**

I

**2.1.2 OPERATE** (on the lower lef t of the front panel )

I

A push butt on con troll i ng the power to the S200 electronics. Press the button once and the 5200 elect ron ics is ready to use (assu m ing you have power on and VACUUM ready, indica ted by the column and chamber vacuum p ush buttons being illu m inated). Press the con trol a second time and the **electronics is turned of f , the instrument is safe to leave for**

I

I long periods, e.g. overnight or for weekends or longer per iods.

The OPERATE switch will not funct ion unless you ha ve power

**switched on, but can be used with vacuum either pumped or vented. If vacuum ready has not been achieved then certain** operate f unctions will be i nhi bi ted. These include supp l i es to the elect ron gun, collector system and displays. Thus, wi th opera te on and vacuum not ready, the displa y tube will be blank and i t is saf e to change the speci men or the filamen t. It is normal practice to change specimens wi th the 5200 in the opera te mode.

I

I

When switchi ng to OPERA TE, or achievin g vacuum ready, there will be a few seconds delay before a raster is seen on t he visual display. This dela y is to allow the electron ics to "warm up".

I

* 1. **Electron Optics Control** (figure 2.2)

Consists of a group of fourteen cont rols and three indicators situated to the right of cen tre of the control panel. This seems a large number of controls (but in normal use) only a few of them are f requently used e.g. FOCUS, RESOLUTION and STIGMA TOR.

I

I

I

I 19

* + 1. BEAM.

I

A push butt on swit ch and two LED ind ica tors. Press the bu tton and the elect ron beam i n the column is turned on. When the BEA M push but ton is depressed the accelera tion **vol tage and f i lament current, at va lues selected by their** respect ive controls, are applied to the electron gun.

I

**Two "fault" i ndicators are posi tioned above the beam swi tch.**

These are:

1. Filamen t Fail; the lef t hand one of the two ind ica tors. ff BE AM is selected on and no filament curren t is flowing, this LED will il lumina te. This means that either the

I

f ilament current con trol is turned to too low a value (set

I

i t to the centre graduation) or that the f ilamen t requ ires changing. (See Rou tine 6 in chapter l or 3.3.7 for

deta ils.)

I

1. Trip; the ri ght hand ind ica tor. If BE A M on is selected

**and, for any reason, the current drawn from the eht**

**suppl y exceeds a preset "safe" level , the eht wil l "trip"**

I

and t he LE D will i llumina te. The tri p is normally caused **by a temporary current surge, or "flash over", in which** case the beam can be reset to on by pressing the BE A M switch twice. If the tr i p persists i t indicates tha t either the low KV anode is f itted with h igh KV selected, the gun components (grid and anode) need clean in g, the fi lament has moved of f cen tre of the grid or, ver y ra rel y, that the eht set has malf unct ioned. For deta ils of gun componen t cleaning and per form ing a f i lamen t change, ref er to cha pter 3 of this manua l.

I

I

* + 1. ACCELERATION VOLTAGE.

Ii

A group of t hree con trols labelled

ACCELER A TION VOL TAGE

I

High Fine

I

ACCELER A TION VOLTAGE

A set of si x push bu ttons which selects the accelera tion vol tage applied to the gun. Press any bu t ton to select the accel eration vol t age which is prin ted above the bu t ton (i f the High bu tton is depressed) or below the but ton if Hi gh is not selected.

I High.

A single push button switch which selects the range of

accelera t ion vol t age available. Press the bu tton (so that i t rema i ns i n) and the range of accelera tion vol ta ge is from 4kv t o 30k v. Press the button again (so that i t remai ns out) and the r ange of accelera t i on vol tage is from 0.3kv to 3.0kv.

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I **Fine.**

The actual accelera t ion vol tage applied to the gun also

depends on the sett ing of the f i ve posi tion rotary swi tch labelled Fine. When this switch is f ull y clockwise the acceleration vol tage will be the val ue selected on the accelera t ion voltage but tons. Turning this switch ant iclockwise reduces the accelera tion vol tage in small steps. On the high ranges of accelerat ion voltage the swi tch changes the accelerat ion vol tage in steps of lkv. On the low range each step is O.lk v.

I

I

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**By using these three controls the accelerat ion voltage can be** changed in i ncremen ts of O.lkv from 300 vol ts t o 3.0kv and in **increments of lk v f rom 4k v to 30k v. When an acceleration**

I

vol t age of either 5kv or 0.5kv is selected some of the posi t i ons on the fine swi tch will have no ef fect.

The actual acceleration vol t age selected is always d isplayed in the Data Zone at the top of the visua l d isplay and the m icrograph.

I

The accelera tion vol tage used i n any particular situa t ion will depend upon a nu mber of factors determined by the nature of the specimen and the t ype of informat ion you are try i.ng to get from i t. While you are learn ing to use the 5200 i t is easier to use a met allic sample and a hi gh acceler ation vol tage. Try 25kv.

I

When usi n g accelera tion vol t ages of 3kv or less the low kv anode should be fitted to the gun. For details on changi ng the anode see Rou t ine 7 i n chapter 1 or section 3.7.

I

A few genera l rules are that a high accelera tion vol tage gives **be t ter resolution on robust, conduct i ve spec imens. A low** acceleration voltage causes less charging and specimen da mage on delicate, non-conducti ve samples (e.g. biologica l materi a l). A high vol tage is needed for the ef f icien t **generation of X-rays for specimen analysis, a low one for** look ing a t t he surface of semiconductor samples wi th mi n i mum bea m penetra tion. The select ion o f the correct vol tage for d i f f eren t t ypes of sample will be discussed more f u lly i n chapter 5 of this man ua l.

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All the 5200 electron optics and scanning circui ts are **compensated for changes in acceleration vol tage. When you** select a di ff erent vol tage the con trol circui ts also change the eff ect of the RESOLUTION control (via the OPTIBEAM circu i ts), the MAGN!FICA TION con trol and the FOCUS con trols. The net resu l t of this on the visual image is tha t nothi ng appea rs to change, the magnif icat ion, focus and picture br ightness stay const ant. Only the eff ect of beam energy on the sample changes.

I

I 21

* + 1. Filament.

I

Controls the amount of current flowi ng through the filament,

and so i ts elect ron emission character ist ics. The cen tre

calibra tion mark round the con trol corresponds to a filamen t

I

current of 2.75 amps, each small div ision represen ts a change of 0.05 amps.

The correct method of setting the filament current requi res the use of the EMISSION IMAGE and GUN A LIGNMENT

I

controls and wi ll be fully descr ibed in sect ion manual.

I

* + 1. RESOLUTION Coarse and Fine.

2.6.4

of this

A twelve posi t ion rot ary swi tch labelled Coarse and a three turn poten tiometer labelled Fine which controls the size and i n tensi t y of the elect ron beam reaching the sample. In normal operation the Fine control is kept i n the "cali brated" posi t ion (f u lly clockwise) and Coarse on ly is used to con trol the beam i n tensi ty. To see the eff ect of the RESOLUTION

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I

control select a "low" resolu tiont abou t Coarse posi t ion 3 wi th the Fine f u lly clockwise, obtain a TV picture a t low rnagnif ication and f ocus it. Increase the ma gn if icat ion, focusing as you go. Not ice the clear, no ise f ree i mage. Soon you wi ll reach a magni f ica tion when the i mage will not come sharp i n spite of your ef forts to focus i t. This will ha ppen at about S,000 t imes. Check that you ha ve signa l level auto selec ted. Turn the RESOLUTION up to abou t posi tion 8 and refocus. The image will now be sharper and you can go to h igher magnificat ions. A t magni ficat ions of 50,000 and above you will need a RESOLUTION settin g of 11 or 12 to achieve the u l timate resolu t ion performance.

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You will notice that as RESOLUTION is increased the i mage will become more noisy, l ike looking through a snow storm. This is the unfort una te and unavoidable resul t of increasi ng

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the resolution. The operating techn i que to use is to start at

I

low resolution at low magnif ica t ions and increase the resol ution only as far as you must to achieve the picture quali t y you need. (The noise on the pi cture can be red uced by usi ng slower scan speeds, V is 2 or Vis 3. Try it. The noise reduct ion wi ll be even grea ter on the micrograph when you take one.)

I

* + 1. OPTIBEAM.

I

A control labelled Normal and an indicator labelled Change Aperture.

The OPT!BEAM system computes the best lens exci ta t ions for use under any operating condi t i ons and sets up t he lenses to give optimum performance. To achieve this OPTIBEAM must know many thi ngs about the operating cond i tions that you have set. Most of this i n forma tion is fed in automatica lly, but there is one import ant parameter that OPTIBEA M does not know. This is, the si ze of the final apert ure. The normal final aperture size for OPTIBEAM is 20 micron and if the NOR MAL switch is depressed then OPTIBEAM assumes that th is is the size in use. (You must

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22

**select the f i nal aperture size usi ng the final aperture selection controls on the column, see section 2.9. It is recommended that a 20 rnicron aperture is fitted in apertur e**

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I

**posi t ion 2, wi th the aperture centring controls being set at**

about X=6mm, Y=6mm ).

Under certain oper ating cond itions, part icularly a t long working d istances and low accelera tion volt age OPTJBE AM **may need to use a dif ferent size final aper ture to achieve** optimum per formance. It tells you this fact by illuminating the Change Aperture indica tor. To ma in tain opt imum **performance you must select the 50 micron aperture using the aperture changer controls. This is normall y i n aperture posi tion 4 wi th the aperture changer m icrometers set at** abou t X =6m m, Y=l8mm. (These sett ings may vary sl ightly between machines.) When you have selected the alternative

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aperture, tell OPTIBEAM by releasing the Normal switch.

I

For normal operat ing just check that OPTJBE AM is switched to Normal, the EMITTER switch is out, ie not LaB6. Ignore the Change Aperture LED, set the Fine con trol fu lly clockwise and just use the RESOL UTION con tro l as descri bed **above.**

* + 1. EMITTER LaB6

This switch has three f unct ions, all of which are needed when t he opti onal LaB6 emitter assem bly is used. These functions are

I a. Change the level at which vacuum ready is i nd icated

..

1. Change the emission current from t he EHT set to the level requi red by the LaB6 emitter, and
2. Correct the OPTIBEAM circu its for the diff erent performance characterist ics of the LaB6 em itter.

If the normal t ungsten filamen t is in use set this control to the non LaB6 posi tion (switch out). If you have the optional LaB6 fila ment fit ted, swit ch to La86 and read section 4.2 of this manual.

|  |  |
| --- | --- |
| I |  |
| I |
| I  I | 2.2.7 |
| I |  |

Note: If a conjugate beam blank ing opt i on is f itted the use of the Normal and Change Aperture con trols wi ll be slightly di f ferent, see section 4.5.

FOCUS - Coarse

* Medi um
* Fine

A set of controls which allow the user to adjust the current in the objective lens, thereby adjusting the posi tion i n the chamber at which the electron beam is focused.

Select a very low magn if ica t ion (switch the MAG NIFICATION to Coarse and spin the Change control several tu rns anticlockwise). Turn the FOCUS Coarse con trol. The image goes i n and out of focus. Focus as well

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as possi ble, increase the magnif icat ion and f ocus again. Repeat this process. At magn ifications of 100 t imes and above it will not be possi ble to obt ain an accurate focus usi ng the Coarse con trol . When this point is reached, start using the Medi u m focus control. When the magn if ica tion reaches i n the region of lOK X (as indicated on the data display on the top of the visual d isplay) i t will aga in be difficu lt to accuratel y focus. Start usi ng the Fine con trol. Take care not to adjust Coarse or Medi u m focus when work ing at hi gh magn i f ications or focus ma y be completel y lost, requi ring the operator to return to low magnif ications and use the Medium f ocus again. (It wil l be necessary t o increase the resolution as the magn ificati on is increased.)

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An image wh ich is in f ocus at h igh magn if ica t ions wi ll be in even better focus at lower ones. So, for the best pictures, turn the magn if icat ions up, f ocus and then return to the requi red magn ificat ion.

I

I 2.2.8 STIGMATOR

Two single turn con trols af f ecting the amount of ast igmat ism correction app lied to the electron bea m. Asti gmat ism i s when the focus of the image is good i n one direct ion, but i t looks smeared in a dir ection per pendicular to tha t. In a perfect electron microscope stigma tors should not be needed, but in a "real" microscope small imperf ections in the lens and con t aminat ion in the column means that stigmat ors are necessary. (Ast igmat ism can also be caused by many other varied ef f ects, includ ing ma gnetic samples).

I

I

A sim ple method of usi ng of the stigmators will now be described.

Set both stigma tor controls to thei r cen tral posi t ions wi th thei r knob poi nters vert ica l. Obtain a well focused image at a magnification of 10,000 ti mes. Now adjust one stigma tor con trol, going f irst one side of cen tre and then t he other. The image wi ll go i n and ou t of focus in one axis. Select the setting of the st igmator con t rol which gives the best i mage. Now repea t this exercise wi th the other stigmator, selecting the setting which gives the best image. The im age resolu t ion may now be f u rther improved by repeated small adjustmen ts of focus and stigmators. For f urther details see chapter 5 of this manual.

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* 1. SCANNING controls. (fig 2.3)

In the following section all scan ti mes and line densit ies are approxi mate and are quoted for an 5200 set for 50hz power. The numbers in brackets are for a 60hz machine.

The scann ing con trols consist of six controls grouped at the lef t hand end of the control panel. (This group is spli t in two by the Signal Level controls.) As each cont rol is descri bed, try it and see what i t does. The con trols are:

24

2.3.l MAGNIFICATION.

Two controls, a push bu tton swi tch labelled Coarse and a d igiknob labelled Change. Turn the Change digiknob **clockwise and the magni f icat ion increases, you see s1naller** and smaller pa r ts of t he sample in greater deta il. Turn the Change digi knob ant iclockwise and the magni ficat ion **decreases.**

Press the Coarse switch so that i t stays depressed. The Change control now covers the lu ll range of magni lications (from 30X to 300,000X at 30kv and 15mm work ing dist ance) i n 15 coarse steps. Now go to low magn ificat ion and press the coarse switch and try the change control aga in. The **magni fica t ion wiH now increase in much smaller steps, taking** 211 steps to cover the fu ll range. The i n terchange between coarse and fine can be made at any time.

I

The magnifica t ion select ed is shown in the data zone at the top of the d ispla y. The magni fication range ava i lable depends on the work ing dist ance and the accelerat ion vo ltage **used. At long working distances it wi ll cover a lower range**

I

e.g. from 7X to 55KX a t lOOm m worki ng distance and 30kv. A t low acceleration vol tages the range covered will also be lower e.g. f rom lOX to 90K X at 3kv and 15mm work ing distance. Other typica l va lues are

I

|  |  |  |  |
| --- | --- | --- | --- |
| KV | Worki n g | **ivti n** | Max |
|  | Distance | Mag | Mag |

I""

If t he lowest magnif ica tion is selected and then the

|  |  |  |  |
| --- | --- | --- | --- |
| 30 | 15m m | 30X | Z BOK X |
| 3  300V | 30mm lOOmm | 6X  0.6X | 50l<X  5K X |

accelerat ion voltage is increased the d igiknob Change control

will have to be turned some way before t he mag nificat ion actually changes.

I

IMAGE SHIFT <--}and ***t***

I

Two controls which move the scanned raster across the **speci men in the X and Y axes a distance of 40 microns (at** 15mm work i ng dist ance). These controls can be used to give apparent f ine specimen movemen ts a t h igh magnifications when the stage m icrometers have become too coarse. They are most usef u l at magn ifications in excess of 10,000 t imes.

Turn the **H** control clockwise and the ima ge will move right across the display. Turn i t ant iclockwise and the image wi ll move lef t. Now t ry the ef f ect of the control.

**t**

2.3.2 SCANNING MOOE

A ban k of si x push buttons labelled SCANNING MODE and a single push button labelled PHOTO Start/Reset.

-- ----------------------------------------

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I 25

The SCANNING MOOE switch incor pora tes the following f unctions:-

I

TV.

I

**VJhen selected gives a standard television scan for** flicker free viewing. A CCTV output is availa ble in the 5200 to allow images to be d isplayed on a remote TV monitor or recorded on a v ideo tape recorder. The line densit y on TV is 625 lines on 50hz power, 525 on 60hz power.

I

(The CCTV ou tp ut socket is mo unted on the rear of the small tri m panel to the lef t of the visual d isplay.)

I

I SMALL.

A 12 (15) frames per second 625 (525) line scan co vering one n inth of the d isplay ar ea, in the cen tre of the d isplay. This small no ise free raster is most usef ul for cr i tical focusing and ast i gmatism **correct ion at high magni f ications.**

I

Vis l.

A 12 (15) frame per second 625 (525) line f ull frame scan for less noisy flicker free vi ewing.

I

.•.

Vis 2.

A 3 (3.75) frames per second 625 (525) line r aster for even bet ter no ise red uct ion on the i mage.

V is 3•

A 5 (4) second per frame 625 (525) line raster for **the ultimate in noise free visual obser vations of images.**

I Fast.

When depressed i t selects the faster of the two

I

record speeds. Fast is used for the major i t y of **micrographs, when the ultima te in noise reduct ion is** not needed. Slow is used for very high resol u tion work. It is also usef ul for signa ls with a poor frequency response e.g. cathodoluminescence, specimen curren t and x-ray analysis. It has no ef fect on any visual scans.

I

The d if f erence i n noise between the t wo scan speeds can be seen on graph. Select Gra ph on the SCAN swi tch on the Image processor on the lef t of the upper control panel. Obtain a noisy image (RESOLUTION sett ing 9 or above) and select Fast. Look at the noise on the signa l. (No ise is t he fine "grass" on the gra ph ). Select Slow and see the noise **on the signal decrease.**

###### I

I 26

PHOTO.

I

A single push but ton below the SCANNING MODE switch. When you have a good enough image on the

I

visual display and you want a photograph of it, just press the PHOTO button. (Assum ing that the record display is correctly calibrated, see section 2.8.4 and the camera loaded wi th a suitable film.) When you press the PHOTO button the visual d ispla y will go blank for a short per iod. This is to allow the auto photo calibrat ion system to work wi t hout you seeing the rat her f unny things that happen to t he 5200 dur ing this period. The auto setting procedure will now be descr ibed but your ability to operate the 5200 will not be af fected i f the next paragraph is

I

I

I not f ully understood.

If SIGNAL LEVEL Auto is selected the sequence is

as follows. When you press the PHOTO button the **scan control switches to V is 1 scan- speed, scans for** a f ew frames and the au tobrig htness circu its **average the signal from the spec i men over this** number of frames. This aver age signal is then adjusted to the level set by the A uto Level control (see section 2.4.l.) The autobr ightness circu i t is then locked at this value. Now the record display is switched on and a record scan (at the speed selected by the Fast switch see 2.3.2) started. A t the end of **the record scan the sanning system returns to the**

I

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I

scan speed that you had set before pressi ng the

photo button. This seemingly com plex sequence happens automat i cally and ensures that all you r photographs have the same exposure level.

**i** If SIGNAL LE VEL A uto is not selected, or Hold is

selected, the same sequence happens but the

au t obrightness system cannot adjust the average

I

**signal, so the photo w ill have the br ightness set by**

the manual level con trol.

* 1. DISPLAY CONTROLS

I

Consists of six controls grouped to the lef t of cen t re of the con trol

**panel. These controls are:**

**2.4.l SIGNAL LEVEL**

A group of f i ve cont rols. These are:

SIGNAL LEVEL Auto

Select A uto (switch pressed in ) and the auto br ightness **system is funct ional. [n this mode the average i mage** intensi t y is set by the auto level control. This level will be mai ntained under all operating cond i tions. Set auto level and then adjust the resolut ion cont rol, the image in tensi t y does not change. To see the ef fect of autobr ightness select auto level off and repeat the above test wi th the resolut i on control, using the Manual level control to correct the i mage bri ghtness.

l.

- - - - - - - - - - -------------------

27

Select non Auto (swit ch released) and the auto br ightness system is of f. The mean signa l level is now cont rolled by the Manual Level control and will not be corrected for changes i n signal level.

I

Auto Level

Sets the signal level to wh ich the auto br ightness system will

I adjust. It only wor ks when signa l level aut o is selected.

Select signal level auto and turn the auto level clockwise, the

bri ghtness of t he i mage on the d isplay i ncreases. Turn i t anticlockwise and the image bri ghtness decreases.

I

If any changes are made to the electron opt ics, final aperture or collector bias which changes the intensi t y of the electron input to the collector system, the autobr ightness circui t will adjust the gain of the signal channel to ma in ta in a constant signal level.

I

I

The normal sett ing for this control is so that, when graph is selected, the video signal almost spans the video level markers (see section 2.5.8 graph).

**l**

Manual Level

Sets the average signal level when SIGNA L LEVEL Auto is not selected. When in this mode the signal level will not be automat icall y corrected for changes in the input to the collect or system.

Hold

..

When this button is depressed the A utobr i ghtness system will be lock ed at its present level. Any changes to the signal wi ll be seen on the displa y. When the button is released the autobr ightness will con tinue f unct ioning as normal.

I

**\.Vhen in the Hold mode the operator has no control of the** signal level, it will hol d the level set by the last autobr ightness sample.

I Con trast

If SIGNA L LEVEL Auto is selected, turn ing the Contrast

control clockwise will increase t he con trast of the displayed image. (The mean signal level will try to drop bu t the Autobr ightness will adjust the gain to ma i n ta in the selected signal level.)

If A uto is not selected, operating the Cont rast control wi ll actua lly decrease the mean signal level. Th is allows the Manual Level control t o be used to gi ve grea ter cont rast.

**The contrast contro l can also reduce the "natural" contrast of the sample, so for normal v iewi ng a small amount of contrast** control must be used. The easiest way to set this "normal" **contrast is to obta in a blank raster wi th no signa l or noise** showing (select non A uto signal level and turn t he Manual Level to mini mu m). Increase Visual Br i unt il the blank raster

I

I 28

is visi ble. Adjust Cont r ast so that the bl ank raster is the same brightness as the background of the data zone. This setting will suffice for a large amount of microscopy and i t is good operating practice to check this level at the start of each operat ing session.

2.4.2 Display controls

A single cont rol sett ing the br ightness of the v isual d isplay CR T. Th is con trol is:

V isual Br i.

I

Sets the br ightness of the visual d ispla y on visual speeds only. It has no ef f ect on the record display. Set the signal level to its 11average'1 value, using auto level and graph, and then ad just V isual Br i to g ive an i mage brightness that is comfortable to look at.

I

An alternat ive method of sett ing th is is to select SIGNA L LEVEL non-Auto and set Manua l Level to mi n i mum to give a blank raster wi th no signa l or no ise showing. Adjust Visual brig htness so tha t the background of the da t a zone is visible.

I

I

Now set Cont rast so tha t the raster is the same br ightness as the dat a zone background. Adjust Visual Br i so that the blank raster is just visi ble i n your ambient room light ing.

This level depends on ambient l ight ing cond i t ions and operator preference, and ma y need to be altered frequent l y.

I

2.4.3 THE KEY PAD

This can be used to enter the phot ograph and specimen numbers into the data zone and to control the l inear measurement cursor. The f unct ion of the ind i vidual keys are:

..

I

A

Switches the output of the opt ional speci men curren t moni tor into the top lef t corner of the dat a zone. If the specimen current moni tor is in measure mode the sequence is:-

I

Press it once to switch this pa rt of the da ta on.

I

Press aga in and the specimen current mon i tor dat a is locked and wi ll not respond to changes i n specimen current un t il i t is unlock ed.

Press the switch a third time and the specimen current monitor data is switched of f.

If the specimen current mon i tor is switched to image mode the sequence is:-

Press once, data on.

Press again, d ata still on. Press a third t i me, data of f .

B

Sequences the Speci men number and the Phot o number section of the data zone. Press it once and t he speci men number will go into inverse v ideo (black numbers on a whi te

I

29

ground). Keys 0 to 9 can now be used to set the Specimen number.

I

Press the key again and the photo number can be entered as above.

I

Press the key again and both number fields go back to normal video and keys 0 to 9 ha ve no ef fect.

I

c

**Press C once to enter cursor POS mode, when in th is**

I

mode:

2 cursor lines will appear on the d ispla y , the micron marker size will be replaced by the cursor separation and POS wi ll **replace the micron marker.**

I

E key moves the cursor lines (both together) t o the r ight. F key moves them both to t he lef t.

I

Pressing the E or F keys momen tar il y moves the cursor one

I

**posi tion.**

Hold ing down E or F causes cont inuous movement. Releasi ng

I the key stops the movement.

**Note: The cursor can only move one posi tion during each**

**f rame scan, so cursor movements wiH be f ast at TV scan and**

I

ver y slow at Vis 3 scan.

Press C aga in to enter t he cursor sep mode. While in this mode: SEP appears in t he data zone.

**i**

The lef t cursor line stays stationa ry wh ile the righ t line

**moves..**

I E moves the line r ight.

F moves i t lef t.

I The keys work the same as for the pos mode abo ve.

Press C a thi rd time to ex it the cursor mode and ret urn to

I

normal data.

While in the cursor mode t he micron marker part of the display is replaced by a nu mber representing the separat ion of the two cursor lines, which can be altered as descr ibed **above. The cursor measurement is correct at al! magni f ica tions, accelerat ion voltages and work ing distances.**

I

If using the cursor in the split screen mode, (see section 2.5.6 and 2.5.7) two things must be remembered.

1. **To make a sensible measurement, both cursor lines must**

be one half of the di splay.

b. If the cursor is in the right half of the display then you

**must divide the separ ation number by the zoom factor.**

I

I 30

D

I

Press the D key once and the entire dat a zone, including any text (see 2.11) will be switched of f .

I Press i t again and the data zone will switch on again.

* 1. **Image Processing Controls (fig** 2.5)

I

This is the group of con trols on the upper lef t control panel. It provides t he following f acilities:

* + 1. Split Screen and Dual Magn ification

I

1. Input Switching
2. Video Processing Signal Mi xing

I

Di f f eren t iator Signal Invert

**Gamma**

I d. Scan Processi ng

I **2.5.1 INPUT SELECT**

Normal Graph **Line** Spot

This is a 4 posi tion switch which lets you select the t ype of

I signal you want to look at. The choices are:- S.E.

Secondary Electrons from the photom ult i plier head ampl i f ier. Although called Secondar y Elect rons the output of the head

I

..

**ampli f ier may be either secondary or ref lected electrons, as** selected by the SE/RE switch. This is mounted on the side of the black plast ic block protruding from the back of the chamber. When the swit ch is forward, t oward the cha mber, t he collector cage is biased posi t i vel y and both secondary and backsca ttered electrons will be collected. When the switch is **point ing backward, away from the chamber, the collector** cage is at ground poten t ial and backscat tered electrons only will be collected.

I

I

I B.S.E.

Backscattered Electrons from an optional backscattered

I

detector. Three t ypes of Backsca t ter detector are ava ilable. These are:

1. Four elemen t solid state detector

I

1. Annu lar solid state detector
2. Scintillator backscat ter detector

**L** These are f ully descri bed in sections 4.10 to 4.12.

X-R A Y

The output from the ratemeter of X-Ray processing equipment or f rom t he opt ional X-Ray processor.

AU X - For any other i nput tha t you ma y have. The i nput sensiti vi t y is lv i n to lOOohms. If an opt ional Specimen Current Moni tor is f itted i t will be f ed into this i nput.

I 31

The input sockets selected by these switches are moun ted on the back of the small trim panel to the right of the visual d isplay.

I

* + 1. SIGNAL MIX.

Allows you to mix the signal selected by the INPUT SELECT switch wi th the secondary elect ron signal to produce a composi te signal which appears on the displa y.

I

Turn the control fully clockwise to get a secondar y electron image.

I

Turn the control fu lly ant i clockwise to see the signal selected by t he INPUT SELECT switch (assuming that you have an opt ional detector fitted.)

I

Turn the cont rol to an i n termed i ate posi t ion to get a linear mix of these two signals•

•

* + 1. INVERT.

I

W ith th is switch in the down posit ion the signal is shown "normally" on the display. This means that areas of specimen which gi ve a large signal to the detector appear as bright areas on the picture. When the switch is up the signal is inverted and the picture on the display will appear as a negati ve, i.e. with whi tes being black and vice versa. This facility may be used to invert specimen current ima ges, mak i ng t hem easier to compare wit h reflected electron **images.**

I

I

If a normal image is inverted i t can be photographed directl y on negat i ve f ilm to make a slide for project ion.

* + 1. GAMMA.

**i**

When applied, GA MMA makes the video amplif ier behave i n a **non linear f ashion. Low level v ideo signals are enhanced** while high level video is attenuated. This allows the overall **contrast of an irnage to be reduced whi le the contrast i n low** brightness areas is increased.

I

When this cont rol is f ull y ant iclockwise i t has no eff ect on the pict ure. As i t is t urned clockwise the dark areas on the picture begin to get bri ghter, bu t the bright areas stay the **same.**

I

Z.5.5 DIFF.

Processing the video signal by Dif f erent iat ion enhances the detail in low con trast areas by "sharpen ing" the edges of areas of almost equal bri ghtness. When used on low con trast **specimens it shows the boundaries between different areas.** When used on specimens wi th a large amoun t of f ine detail it will enhance t he detail.

When the cont rol is f ully ant iclockwise it has no eff ect on the image. When t urned clockwise i t has ma xi mum eff ect.

I,--"

I 32

I **2.5.6 SPLIT SCREEN.**

I I I I I

I AM2

I

I

Ill

I

I I I

**2.5.7**

Sets the scann ing system into the split screen mode, where

the display is split vert ically into two halves. The lef t half of the display always shows the secondary electron image at the magnification set *by* the magni ficat ion controls. The right half of the display can show one of the following:

1. The same signal a t a hi gher magn if icat ion selected by the ZOOM control.
2. A dif ferent signal, selected by the INPUT SELECT switch, at the same magn ificat ion or a higher magni ficat ion selected by the ZOOM con trol.

***c .* A mix of secondary electrons and one other signal,** selected by INPUT SELECT and MIX, at the same magn i ficat i on or a hi gher magn ificat i on selected by the ZOOM control.

When in the split screen mode, all video processing is done equally on both hal ves of the image.

**Fo r best resul t s on re cord use Spli t S creen on**

**ZOOM. scan spee ds of 2 an d be lo w.**

Operates i n conjunct ion wi th the spli t screen cont rol. Select split screen and ZOOM XI. Both hal ves of the display are at the same magnif icat ion and the zoom factor displayed in the top r i gh t of the dat a zone says Xl. Now select ZOOM X2. The right side of the d isplay increases in magni ficat i on by a factor of Z and the zoom factor in the d ata zone says X Z. A bri ght rect angle on the lef t side of the display (the lower magnification side) shows you where the higher magn if ica tion image comes from. The bright "window" can be moved about on the lef t half of the d isplay using the X and Y POS controls.

The X4 and XS zoom f act ors work in the same way.

While i n the split screen mode t he magn i f ica tion con t rols work as normal on the lef t side of the d isplay, wi th the ri ght half alwa ys zoomed by the selected factor.

If the cursor (sect ion 2.4.3) is being used on the ri ght side of the display, t hen you must d ivide the separat ion number by the zoom factor.

The cursor mode can only be used sensi bly when both cursor

I lines are on the same half of a spl i t screen image.

**2.5.8 SCAN**

IL A four posi t ion switch select ing Normal Graph Line Spot

I

I

I

I 33

Normal.

I

When this is selected the SCAN switch has no ef f ect but one ef fect of the SCAN system can be seen on the d isplay. Somewhere on the display should be a small white squa re, called t he spot. Its posi t ion can be adjusted by the X POS and Y POS controls. It shows the posi t ion of Graph or Spot (see below).

I

I

Jn normal use this square can be lef t posi tione d under the

**data zone so i t is not v isi ble on the i mage.**

I Graph.

Press Gra ph and the picture on the d ispl ay will be replaced by a wa vy line. This is a graph d isplay ing the video in tensit y of one l ine on the speci men. The graph is taken from a line on the specimen drawn horizont ally th rough t he whi te square spot. This can be moved using t he Y POS cont rol. (X POS

I

I will move the spot but will have no ef f ect on the graph.)

Graph is drawn at the line speed of the record raster selected

by SCANNING MOOE and is not intensi ty corrected for photogra phy.

I

On each side of the d ispla y are drawn two short hori zon tal red lines. When i n the graph mode the lower fine represen ts zero video level , or black on a m icrograph. The top line represen ts the maxim um usef ul signa l level , or whi te on a m icrograph. (Signa ls can go above or below the markers but since t hey are outside the recor d ing r ange of the m i crogra ph they are of no use.)

I

I

Select Graph and Auto SIGNAL LEVEL. Adjust A uto Level and Contrast so that the Graph almost spans the ma rkers. Switch back to Normal. The image on display is now using the f ull dyna mic range of the vid eo system.

**i**

I Line.

This gives a graph ical d isplay as descri bed above. The i mage

I

is a graphical represent a t ion of t he signal intensi t y on a line drawn hor i zon tall y across the sample through the spot. The ma in d i f f erence between Graph and Line is that of speed. Graph is drawn qu i te f ast, at record l ine speeds. Line is d rawn slowly, each Line scan tak ing t he f rame time selected by the SCANNI NG MODE swi tch. Each line scan can be as

I

long as 200 seconds if slow record is selected.

I

It is used t o generate graphs of signals tha t requi re a slow **sampling rate to give a stat ist i call y correct pi cture,** pa rt icular ly X-Rays and Cathodoluminescence.

When in the Line mode you wi ll see that the l ine drawn **consists of a number of discrete points. The s i gnal is being** "chopped" to ensure that the brightness on the visual display is not too high, and to control the photographic exposure on the record uni t.

I

**If Li ne is used on visual speeds, you should ei ther l ock the autobrightness or select manua l br ightness control. A lso**

I

34

Visual Br i may have to be increased to make the Line visible at the faster scan speeds.

I

Spot.

I

Switch back to Nor mal on the Image Processor. Move the X and/or Y POSITION controls to place the br ight square on some f eat ure on the picture. Switch off the autobrightness. Now switch t o Spot. This w ill stop the scan in the column and park t he beam at a point i nd icated by the centre of the square. The square itself will have a br ightness equivalent to the signal at that poi n t on the speci men.

I

Note: If an X-R ay processor option is f itted then t he funct ion of some of the SCAN controls will be altered. For deta ils see section 4.3.

I

* 1. Beam Processing Controls (fig 2.6) • Consists of a nu m ber of controls grouped on the upper r ight con trol panel. It prov ides t he f ollowing facili t ies:-

I

* + 1. FOCUS MODULA TION - Focus wobble

l - Dyna m ic Focus

b. TILT CORRECTION

1. GUN ALIGNM ENT - EMISSON IMAGE
   * X and Y Til t
   * X and Y Shif t

2.6.l FOCUS MOD

Of f

This is the "off " switch. When i t is selected t he FOCUS MOD controls are inopera t ive

Focus Wobble.

I

Allows the f inal aperture to be centred on to the electron optical axis of the colu mn. Select TV and obt ain a focused image at a magni ficat ion i n the range from lK X to lOK X. Switch to Focus Wobble. Turn up t he CHA NGE con trol. The picture swings in and out of focus, by an amount varied by t he Change control. If the im age also moves la terall y on t he display the f inal aperture is not centred. Ad just the aperture centring m icrometers for mini mum pict ure shif t (as in section 2.9).

I

I

Dynamic Focus.

When a sample is viewed at a very high angle of til t it will not be in focus all over. If i t is in focus in the cent re it will be ou t of focus at the t op and bott om of the slope. Dynamic Focus corrects for this by add ing some of t he vert ical scan on to the focus. The amount of scan added is adjustable with the CHANGE control. It works best where t he plane of t ilt is in the vertical axis of the screen. This will occur at 15m m working d istance. At any other work ing distance, scan rotation can be used to rot ate the scan t o align wi th the

I



I

I 35

plane of tilt. This condit ion is f ulfilled when the stage movemen ts appear hori zont al and vert ical on the displa y.

I

**Dynamic**

**n".**

**There are two Dynamic Focus switches; "+" and**

Focus + is regarded as normal in that the speci men is til ted towards the collector system i.e. the top of the picture is at **longer working distance. Dynamic Focus - is for a speci men**

I

which t il ts away from the collector.

I

There are two methods of setting up Dynamic Focus. For the f i rst method switch to TV and focus the centre of the image. then at VIS 2 or VIS 3 scan speed use the CHANGE control to

I focus the picture at the bottom of the screen.

The second method uses some of the controls on the image

processor. First use the Y POSIT!ON cont rol to put the spot **at the centre of the screen's vert ical axis. Now swi tch to** Graph. You can then adjust the FOCUS cont rols on the ma in instrument to obta in n ice sharp peaks and troughs on the Graph waveform. You will f ind this easi er i f you select slow scan speed. Next turn the Y POSITION con trol f u ll y

I

I

anticlockwise, and focus aga i n, this t i me with the CHANGE contro l. You should end up wi th a nicel y focused picture. If you need to change magnif ication there is no need to readjust **the controls, as Dynamic Focus is compensated f or changes in** magnification (and acceler ating vol tage.)

I 2.6.2 **Change**

Controls the amount of Focus Wobble or Dynam ic Focus.

Turn i t f u ll y anticlockwise and the Focus Wobble and

I

Dynamic Focus have li t tl e ef f ect. Turn i t clockwise and they

**have maximum effect .**

* 2.6.3 **TILT CORRECTION.**

'

When a specimen is til ted, i t appears to be shorter in the plane of t i lt than it would be i f viewed f ace on. The TILT

I

COR RECTION cont rol compensa tes for this by increasi ng the magn ification i n the vertical ax is on the screen. Aga in, this **works best w i th the speci men til ted in the ver t ical axis. W ith** a flat specimen, you simply use th is con tro l by setting it to the same angle as the surface of the stub the operator must make his or her own judgement as to wha t angle to set, using

I

the stage til t angle as a guide.

I **2.6.4 GUN ALIGNMENT CONTROLS**

A set of f i ve controls which allow the posi tion of the electron

source to be set on the electron opt ica l ax is of the column.

I

They only ha ve lim ited range and requ i re that f ilament a l ignment (sect ion 3.3.7) is done correctl y.

**L Emission image**

Switch i t on and you see a pictor i al representat ion of the emission profile of the filament (see figure 2.10). It is not an i mage of the end of the filament. When in the emission image mode you can use the GUN A LIGNME NT controls to adjust the f i lamen t emission to be on the axis of the column.

I

36

I X and Y Shif t

Allow the source of electrons emitted from the f ilament to be shif ted laterall y over the top of the column so tha t the

I

br igh test part of the source is projected onto the speci men. You should adjust these con t rols so that the bright em ission image is in the centre of the visua l display.

X and Y T ilt

The emission densi t y from the filamen t will be a max i mu m at **one par ticular point on its surface and in one particular** d irect ion. These controls allow you to "tilt" the gun to use the best emission angle of the fila ment. This is not a

I

**mechanical gun**

**til t**

**but an electronic simula tion of**

**i t.**

**The**

correct setting is when the br ightest pa rt of the em ission

I

**·, prof ile is in the centre of the emission ima ge.** 4

One method of sett ing the above controls is now given.

I Obtain an image as descr ibed in chapter 1, rou tine 2. Select a RESOLUTION of 2 or 3.

**l** Set the filament con t rol to the cen tre mar k.

Set t he SIGNAL LEVEL switch to Auto and the A uto Level

control to centre tra vel.

I

Switch on t he EMISSION IMAGE.

Usi ng the X and Y Shif t cont rols in the GUN ALIGNME NT group, cent re the bri ght area on the visua l displa y.

I

Select a RESOLUTION of 7 or 8. Usi ng the X and Y Tilt controls, cen tre t he br ightest pa rt of the brigh t spot on the display. If the picture is too bright to allow detai l t o be seen in the emission image, t urn down the A UTO LEVEL control.

I

I

Set the f ilament current to give the requ ired opera t i ng condit ions. The emission image w ill look somethi ng like those shown in figure 2. 10. For norma l operat i on t he

I

filament current should be adjusted to give an em ission profile as shown in f i gure 2.10.3. This should be wi th the filament control knob somewhere near the centre ma rker of the scale. Do not worr y if i t is not at the cen tre marker as i t varies wi th dif ferent filamen ts and wi th the age of the filament. As a f ilament gets older the Filament control should be reduced to ma intain this emission profile. This setting should give good perfor mance wi th a lon g filamen t l if e.

I

37

The ultima te resolution of the S200 will be better if the filamen t cur rent is increased to gi ve an emission profile as shown i n f igu re 2.10. 5 bu t the filament l if e will be shorter.

**2.6.5 Scan Rotation**

**Scan Rotat ion consists of two controls and a digital readout.**

Off /Cou rse/Fine

When Off is selected, Scan Rot ation has no ef f ect, independent of the readi ng of the angle d isplay.

**t** When Fine is selected the Change control rotates the image in 1 degree increments cont inuousl y from 0 to 360 degr ees.

When Coarse is selected the Change control rot ates the

I

**image in 10 degree increments.**

**You can swi tch from Fi ne to Coarse, or back again, at any** t ime. The coarse 10 degree increments will start at the angle set by the Fine control , and vice versa. The Scan Rot ation can be lef t set at any predetermined angle and switched on and off.

I

The Scan Rotat ion wi ll reset to zero when the S200 OPER ATE is switched of f.

I

CHA NGE

Changes the angle of Scan Rotat i on.

I

* 1. **VACUUM CONTROLS (fig 2.7)**

This group of controls, mounted on the front of the plinth, switch and moni tor the vacuum system of the S200. Some of the cont rols on this panel are on l y operative when the gun pum ping opt ion is fitted. The basic system is descr ibed here. l f you have the ion pump option fitted please refer to 4.1.

I

I

The standard controls consist of:-

* + 1. **CHAMBER Vacuum**

I

A green push but ton con t rol ling the basic vacuum system of the 5200.

I

Press i t once (so that the bu t ton stays depressed) to start the pumping system and pump down the column and chamber.

When a work ing vacuum has been achieved (vacuum ready)

I

the switch is illu m inated. Press the switch aga in to turn of f the vacuum system and vent the colu mn and chamber to a i r. (Re lease the clamp on the stage fron t plate if pressurised dry ni t rogen backfilling is being used.)

This control will not oper ate un t il power is switched on, but i t can be used independentl y of the operate switch. If the **vacuum system is vented w i th operate selected, then certain** operate f unct ions will be inhibi ted. These include the supplies to the electron gun, collect or system and the d isplays.

38

Note: It is good pract ice to check t hat the beam is switched off before ven t ing the vacuum system. f t is also advisable to keep the column and chamber **under vacuum when the 5200 is not i n use.** Prolonged exposure to air may cont aminate the inside of the elect ron optical system, leading to long pump down t imes and possibl y degra ded instrumen t performance, pa rt i cular ly in atmospheres of high humidi ty.

I

The 5200 vacuum system is designed for continuous

I operat ion and is fu lly protected aga inst failure.

* + 1. Pressure readout

A bar LED meter, cal ibrated in TORR, showing the vacuum in t he column and cham ber, as selected by the Column - Cha mber swit ch.

I

I

* + 1. Col-Chamber

Selects whether the vacuum readout displays the vacuum in the column or the chamber.

l

* + 1. Column Vacuum
    2. Valve Status

I

) Descri bed in section 4.1

)

2.8 Record Unit Controls and Calibration (fig 2.8)

These controls are mounted on t he back of the record u n i t top panel, behi nd the camera mount.

2.8.l Brightness

Adjusts the bri ghtness of the record CR T onl y. f t has no effect on the visua l displa y.

2.0.2 Contrast

I

Adjusts the contrast of the record CR T only. f t has no eff ect on the visual display.

I 2.8.3 Film/ASA

Adjusts the in tensit y of the record d isplay to com pensa te for

d iff erent types of f ilm (assuming the camera has been set at the correct aperture). Since diff erent types of fil m of the same nomi nal film speed vary in sensiti vit y to the blue light emitted by the record CRT the Fil m ASA cor rect ion cannot be made tot a lly accurate and t he system may have to be calibrated for di f ferent f ilm t ypes.

I

* + 1. Calibration

This section outlines the complete proced ure for calibrating the record uni t. The settings result ing from this should not need to be adjusted f requentl y, but should be checked periodica lly (say once a month) or when good m icrographs are not obta ined consistent l y. Long ter m changes may arise due to t he age ing o f componen ts such as the CR T.

I

I

39

The ca libration procedure is:

* + - 1. Select the appropriate lens aperture for the f ilm and camera back as follows:-

Fil m Speed ASA

50 to 400

800

1600

3200

Ca mera Type

405 or 545 7Dmm, 35m m, 120

f8 Ill

Ill fl6 f22

and check that the lens and spacers are in the corre ct posi t ion for t he back being used (see f igure 2.11).

I

2. Set the Record Br i and R ecord Cont con trols to

**zero\_**

**L** 3.

I

Select a black video level as follows:

Obtain an image at a resolu tion setting of about 6, set signal level to non auto and then select bea m off . Select graph and adjust contrast so tha t the signa l level disp la yed is level wi th the lower signal level markers. The graph should be a straight line.

1. Put a film in the camera, open the ca mera shu tter (if i t has one) and start a photo scan by pressing the

I PHOTO button.

1. As the scan runs increase B RIGHTNESS amount, say 0.1 turns every 5 seconds. **produce a grey scale on the photo.** BRIGHTNESS setting in relat ion to posi t ion.

I

by a sma ll

Th is w ill Note the

**the scan**

I 6.

I

7.

8.

Develop the film. Study i t and choose a BRIGHTNESS setting which just causes percept ible lighten ing of the film. Set BRIGHTNESS to this val ue and lock the control.

If no greys ha ve been achieved, or the grey steps are too widely separ a ted for an accura te setting to be made, repeat this test over a h igher brightness **range or using smaller increments.**

Select a whi te video level by in vert ing the black level using the INVER T switch.

Load a f ilm and start a photo scan. As the scan runs increase the CONTR AST con trol by a small amount, **say 0.1 turns, every 5 seconds.**

I

I 40

9. Develop the film and choose a CONTRAST setting which just produces a sat ura ted wh i te on the photo. Set this level on the CONTRAST control and lock i t.

I

I

If the cont rast steps are too small or coveri ng the wrong range, repeat the test wi th smaller steps or over a di f f erent range.

I

10. Check the sett ings of BRIGHTNESS and CONTR AST by taking a micrograph of a suitable sample, sett ing the video signal level to cover (near ly) the f ull video

I level range, as decribed in section 2.5.8 Graph.

Uncal LED

I

If the Uncal LED is illum inated then the Reco rd scan speed selected is too fast for t he film speed selected by the Fi lm ASA con t rol. When th is happens you must either select the slow photo speed or use a slower t ype of film.

I

2.9 **Final Aperture Centring (fig** 2.9)

I

Good images can on l y be obt a ined from an SEM in wh ich the f inal apert ure (or the projected final apert ure) is correctly cen tred onto the electron optical axis of the final lens. If the final aperture is not correct l y aligned, image shif t w ill occur when the focus is adjusted.

I

The f i nal aperture mechanism of the 5200 holds fou r aper tures wh ich **can be interchanged and adjusted under vacuum, by the two** m icrometer controls situated in the side of the column just above the cha mber. The method of adjustment is as follows:-

I

1. Select the required apert ure size. The recommended aperture sizes and the correspond ing m icrometer settin gs are

**Posi t ion** A perture **Micrometer Micrometer**

Size x y

I

* 1. 20 m icron 6 0
  2. **20 micron** 6 6

I

1. 50 m icron 6 12
2. 50 m icron 6 18

The micrometer readings may vary slight ly on dif f erent instruments. The aperture size fitted in any posit ion may also **var y, depending on particular requirements of the instrument** operator.

1. Obta in a TV rate image at about lK X magnificat ion.
2. Select Focus Wobble and increase t he CHANGE control (both on the FOCUS MOD swi tch ) so that the i mage is "wobbling" in and out of focus.

L

4. Ad just the aperture centr ing con trols to give zero image shif t wi th changi ng focus.

I 41

5. Increase the magn i fication and repeat steps 4 and 5. Continue unt il the image shif t is sma ll at 100 K X.

I

**2.10 Tl-E DATA ZOf\E**

I

In add i t ion to the controls described above there is one other very important part of the S200 control system, the data displa y. This is an area across the top of the display showing all the important

I oper ating parameters of the 5200. I t looks like th is:

27PA lOlKX 25KV WD: 5MM 5:12345 ZOONM • - - - -

I

The significance of this string of information is:

P:67890

X4

27PA

I

Informat ion coming from the optiona l Specimen Current Mon i tor, i f fitted. (See section 4.7.)

I lOlK X

The magn if icat ion of a m icrograph when tak en on the stand ard 5 inch X4 inch Polaroid camera suppl ied wi th the 5200. The magnificat ion is correct at all accelera t ion vol tages and working d istances. The magnif icat ion on the

visua l displa y is approxi matel y 1.6 t imes greater than this.

I 25KV

The value of the accelerat ion voltage selected.

'

W D:5MM

The distance from the poi n t of the sample which is in focus

**i** to the f inal lens.

S:l 2345

**An operator selected speci men number For the method of**

I

selecting this nu mber read section 2.4.3 THE KE YPAD.

P:67890

The number of the next micrograph to be t aken. The start number of th is sequence can be selected using the keypad, and the num ber is then automa t icall y incremen ted each t ime a micrograph is taken.

200NM - - - - -

The micron marker. The lengt h of the bar i n the example shown is 200 nanometers. This marker is correct on both the visual displa y and the microgra ph at any accelerat ion voltage and work ing d istance.

I

L

If the da ta system has been pu t into the cursor mode the **micron marker will be replaced by a number, in inverse video, represent ing the separat ion of the two cursor lines. The use** of the cursor is descr ibed in section 2.4.3 THE KE YPA D.

I

(Inverse v ideo is dark n u mera ls on a light background.)

I 42

I X 4

The Zoom factor i n use, if SPLIT SCREEN is switched on. In the data zone drawn above the magnif ication of the lef t image is lOlK X, that of the right image is 404K X. (A r ather

**opt imist ic example but the numbers were chosen to show the**

**maximum number of char acters available in the data zone.)**

I 2.11 The Text Facility

This allows the user to write over the whole of the SEM display usi ng

t he keyboard.

I

**There are two main faci l it ies provided. These are:-**

1. the ability to place text on the SEM screen in any position for the purpose of providing informat ion about the speci men or **operat i ng condi t ions.**

I

I

b. the abilit y t o store up to 16 tit le messages i n a temporar y memory and to recall them at will for giving ti t les to micrographs.

**l** 2.11.1 **Text** Screen Format

The Text writ ing area starts im mediatel y be low the Da ta Zone and consists of 24 rows of 50 cha rac ters. The

I characters ava ilable are:

Uppercase letters A-Z

I

Numerals 0-9

Symbols !"lf$%&"0=-"+;:<.>.?/\*

* 2.11.2 Writing Text

Af ter the SEM power is switched on yo u wi ll not ice a question mark on a flashing video background in t he top lef t

corner of the screen im mediately under the Data Zone. If

I

**the vi deo level is low in th is region then you may not notice** the flashing background. This character is called the CURSOR and indicates the current wr it ing posi tion. (It may not be visible on a TV raster, try Vis 1).

I

If a key is typed on the keyboard this let ter will replace the cursor and the cursor will be moved one posi t i on to the r ight. **This process repeats as more characters are t yped until the** end of the line is reached. A t this point the next character

I

ty ped will replace the cursor as usual but the cursor wi ll move to the begi nn ing of the next line. If any key is held down t he aut orepeat facility w ill cause a continual string of letters to be printed.

L If a new line is re quired before the end of a l ine then just press CR on the keyboard. A full screen of te xt can be typed

i n this wa y. When the bott om righ t corner of the text screen is reached the cursor returns to the top lef t corner.

i

43

Z.11.3 Editing

There are fi ve keys on the keyboard whi ch are used in edit ing the screen text. These are:

DEL.••.•.••Delete key

If you mistype a char acter you can remove tha t character using t he DEL key and t ype the correct character. Similar ly, if you want to delete severa l characters or a whole word then hold down DEL and the cursor will backspace deleting characters as it goes.

To use the arrow keys, hold down the SHIFT key while pressing the arrow key.

RIGHT ARF<.DW LEFT A RROW UP ARROW DOWN ARROW

Move cursor to the r ight Move cursor to the lef t Move cursor up one line Move cursor down one line

As the descr iptions suggest , these keys move the cursor character in the appropriate direction without alteri ng any of the text on the screen. If the cursor is moved on top of a character then this character is not lost but temporaril y stored. When the cursor is mo ved away f rom this posit ion usi ng one of the cursor control keys then the or iginal character is restored. In this way the cursor can be moved to any posi t ion on the screen, passi ng over any number of words or characters wi thout altering the screen content.

I

If the cursor reaches the right edge of the screen then f u rther r ight movement causes i t to go to the start of the nex t line. Sim ilarly, if the cursor reaches the lef t edge of the screen then f urther lef t movement causes it to go to the end o f the next line above.

I

If the cursor reaches the top edge of the text screen then i t

I re-appears from the bot tom of the screen and vice versa.

The cursor can be used to move to a particular poi nt on the

screen to wr ite a new word or it can be used to edit a mistake embedded in a block of text. This ed i t ing role is carried out as follows:-

I

1. Using the cursor contro l keys, put the cursor over

I

the char acter to be deleted.

1. Type the correct character. (The cursor will move

I one place to the right.)

c. Move the cursor away usi ng the cursor control keys.

* + 1. Video Mode

There is a cho ice of video background for the Text characters. The characters can either be superi mposed on top of the SEM video or the SEM video can be turned off behi nd ind ividual characters leaving the character setting in a box. The former case does not obscure much of the

I

I

I

I 44

specimen being viewed but the characters can be difficul t to read on bright or hi gh contrast areas of the specimen. The latter case gives clarity of reading bu t blanks off some of the image.

I

I

The video mode is selected by CTRL V. (This means press V while holding down the CTRL key.) This changes the cursor

character from a quest ion mark to an aster isk4 While the

I

cursor character is an aster isk any chara cter typed on the screen will have a black background behind i t. Pressi ng CTRL and V again wi ll bring back the question mark cursor. The two modes can be used at any t ime to prod uce a m ixture of text wi th a video background and text wi th a black background.

I

I

This vi deo mode f eatur e can be used wi th the cursor control keys to change the video mode of characters already on the screen by just runn ing the cursor charact er over the text using t he cursor con trol keys. This can be done as fa llows:-

I

Say that the word SPECIMEN is wri tten on the screen (in norma l characters) in an area where the video level is quite high, mak ing the reading of the word d i f ficult. We would like to t urn off t he video background behind these characters. Carry out the fallowing steps:-

l

* + - 1. Move the cursor cha racter un t il i t is over the f irst let ter to be changed (using the cursor control keys).

I

I b.

Change the video mode by pressing CTRL and V. The cursor character should now be an aster isk.

* c• Move the cursor over the letters to be changed using the cursor control keys. As the cursor passes over

the letters, thei r video mode is changed.

Note that "black boxes" can be drawn wi th the aster isk cursor to mark areas of interest by just using the cursor control keys to move the cursor around the area. As the cursor moves i t turns of f the video leaving a tra il of black boxes.

I

2.ll.5 Title Mode

In the TITLE MODE the top l ine of the text screen (immed iately under the Data Zone) is reserved far placi ng t itles and is under lined. There are three con trol keys which control the opera tion of this mode. They are two key operat ions which consists of hold ing down the CTRL key and simu l t aneously pressi ng a let ter key. The oper ations are as follows:-

TITLE MODE ON/OFF.......CTRL T

Turns on the TITLE MODE. The first text line will be blank and the second line will be fi lled with hy phens. At this time the t it le memory is empt y. The cursor will be moved from wherever it was located before enter ing the T i tle Mode to the top lef t under the l ine of hyphens. Th is is so that the cursor can easily be moved into the Title line f or crea t ing or ed i t ing t i tles.

I

I 45

Tit les are created by moving the cursor i n to the title line and typi ng as normal. When the tit le is complete typing CR will bring the cursor out of the t i tle line to the start of the line under the hyphens. The Tit le can now be stored.

I

I

When the T i tle Mode is not requi red anymore CTRL T will turn i t of f , erasing whatever was in the t itle line and also the

I

line of hyphens. The titles that have been saved will still rema in in memor y as long as OPERA TE remains on.

SAVE TJTLE •••••.••CTRL 5

I

**W il l save whatever is in the t itle line in a temporary memory.** Th is memory only ret ains i ts informat ion while OPERA TE remai ns on. The characters in the Title line can be in either Video Mode and they will be saved and recalled as such. Up to 16 titles can be stored and recalled at will.

I

EXAMINE TITLES .••••CTRL E

I

Causes the next tit le to be displa yed in the t itle line. The 16 t itles form a continous loop so that when the 16th ti tle is reached the next CTRL E bri ngs you back to the f i rst tit le.

CLE AR SCREEN..••.•.•CTRL C

Clears the screen of a ll tex t. (When the 5200 is f i rst swit ched on the Text screen is automatically cleared.) A ll the text is lost, the ti t le mode is turned. of f (t i tle line and hyphens erased) but the t i tle memory is lef t i nt act. The cursor is ret urned to the top lef t of the screen. The only wa y of clearing the tit le memory is by wr iting spaces in t he t i tle l ine and saving them by CTRL 5, or by switchi ng OPERA TE off.

TEXT ON/OFF••...••.•CTRL B

If the text is not wanted on the m icrogr aph but still saved in memory then CTRL B turns of f t he tex t vi deo. CTRL B also bri ngs the text back again. This is similar in f unct ion to the key D on the console keypad. Whereas, CTRL B just af fects the text, D on the keypad turns of f both the text and the

I

I Data Zone.

I

I

I 46

I 2.11.6 Summary of Key Funct ions

Key Function

I

LEFT ARROW •• • • • • • • • • • • • • • Moves the cursor lef t one

position

RIGHT ARROW • • • • • • • • • • • • • • Moves the cursor right one

I

position

UP ARROW • • • • • • • • • • • • • • • • • Moves the cursor up one line

I

DOWN ARROW • • • • • . . ...• • • •Moves the cursor down one

line

RETURN • • • • • • • . • • • .• .•• • • • .Fills the rest of the line with

I

**spaces and moves the cursor**

to the next line

I

DEL ........................Moves the cursor lef t one

position deleting the

**character it moves over**

I CTRL C .• • . • . • • • . . . • . . . . ...Clears the screen. Text is

lost

CTRL B .....................Turns the Text of f. Text is

I

**retained in memory**

CTRL V .....................Changes the VIDEO MODE

I

? - Normal mode

\* - Video of f

..

CTRL T ..................• ..Turns the TITLE MODE on

•

and of f

CTRL S • • • • • • • • • • • • ..• • • • • ··Saves the current contents of

I

the title line in memor y

CTRL E • • • • • • • • • • • • , • • • • • • • ,Examine and display the next

I stored ti tle

I I

I

I

I 47

I I

I **OFF**

D

I

I •

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I

I

...

I

I I I

**ON**

# D

**OPERATE**

D

I Figure 2.1

Power Switching Controls

f

I

I

48

ISTIGMATOR l

**STEREOSCA N 200**

IOPTIBEAM I EMITTER ACCELERATION VOLTAGE

..

**Change Apenure Normal** LaB, • 10 16 20 "' **High**

0 0

0 D D I I D

0.6 1.0 1.6 2.0 2.6 3.0

COM$6 **M6dium Fine Coanio Fine Flo• Filament Fa11 Q O Trip**

o

0

:()1:. 0 0 []

*:Q'.* 0

• 7

1 12 J

FOCUS LRESOLUTION **BEAM**

Figure 2.2 Electron Optics Controls

Cambr idge Instr umen ts Ltd B-9993

- - ....... - -

49

MAGNIFICATION

**Coarse**

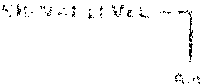
D

I

**Change** I

**Vlaual Ori**

,,,.. .



SCANNING MODE

C mott

VI• 1 Vi.Z V1'3 '' "

I [ I

**Start/Reset**

0 0 0 D

LIMAGE SHIFT J

PHOTO

Figure 2.J

Cambridge Instr uments ltd

Scanning Controls

B-9993

I

I

I """''

CJ ,-- "''

"' a:'l

I

*'!!*

I z"

;: • •

z

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I ' E= •

u

"" 0

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I L......

•

I .. • •

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*e*

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L D .•>.. 0

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I "'''·

I

u.. Q.

C"i

·-- -



l""" - - - - lll!IC· - - - - - 111111 - 111111 111111 -



51

S.E. BSE X - ray Aux INVERT Xl X2 X4 X8 SPLIT Normal Graph Line Spot

I

INPUT SELECT

<D ZOOM I I I I I

I

SCREEN

<D

SCAN

! I I

MIX SIGNAL GAMMA OIFF Y POS X POS

0 0 0 0

## [!]

S.E.

Figure 2.5

Image Processing Controls

Cambr idge Instr uments Ltd B-9993

ii- - - llillllllll lllllll 111111111 lllllllll -



52

ANGLE

D II 1 1 0

FOCUS MOD

Off focus Oynainic Y Tilt X Tilt

Wobble Focus EMISSION

I I 0 IMAGE 0

+

(J)

6 <D Fine a 0

CHANGE GUN

TILT CORRECTION CHANGE ALIGNMENT

Coarse

Off

SCAN ROTATION 0 80

Y Shift X Shift

Figure 2.6

Beam Processing Controls

Cambr idge Instruments Ltd

R-9993

- - -

- - - - -

53

**COLUMN Torr CHAMBER**

**Vacuum Valve**

DJ

**Status**

*-1* \_. -5 -4 -3 -2

10 10 10 10 10 10 **Chamber**

I I I I I I

**Vacuum**

# DJ

0 **(I)**

|  |  |  |
| --- | --- | --- |
| -7 | -6 | -5 -4 |
| 10 | 10 | 10 10 |

**Column**

Figure 2.7

**Vacuurn Controls**

Cambr idge Inst ruments Ltd

B-9993

**!1119** - - 111111111 11111111 - - lllllllll' -



54

0 0 0

**FILM ASA**

50

100 200

400

**Uncal**

**Brightness Contrast**

Figure 2.B Record Unit Controls

Cambr idge Inst ruments ltd B-9993

- - -

- - - - -

55

Cambridge Inst ruments Ltd

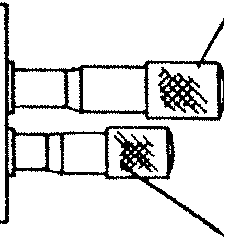
final

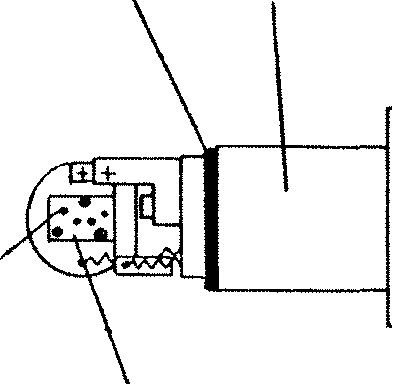
**A pertures**

( 4 )

Aperture changer

1 0' **ring body**





Aperture Clamp Plate

**and SC1'01US**

Figure 2.9

Final Aperture Changer

Aperture

**changer**

y - llhif t

Aperture changer

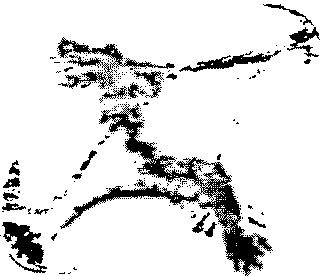
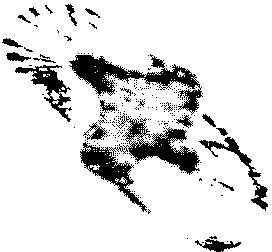
x - llhift

8-9993

I

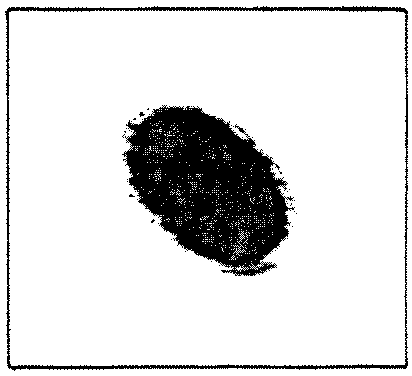
I 56

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| APPROX. I f |  | 2·65A |  | APPROX. If |  | 2•7 A |
|  | 1 | Under -Run | | | **2** |  |
| A PPROX If 3 2·7S A | | | | | | |
| Normal Oper ation | | | | | | |
| ton f ilament life | | | | | | |
| A PPROX. If | 4 | 2 BS A | Optimum Resolution reduced f ilam ent lif | | APPROX If  5 | 30A |

I   I

I 

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I  

l

Figure 2.10

Setting the Filament Current

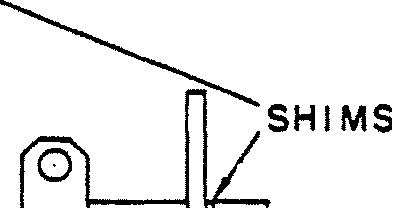
**Note: The improvement in resoluti on at high f ilament current is marginal**

I

• 57

I

I I I I I I



545

CAMER A BACK

B

B

C RT

4 05

70 mm

120

220

g

35 mm

L

LC LENS CA RR IER L LENS

S S SMA LL SPACE R

LS LARGE SPA CE R

35 mm A DA PTOR

I

I

;

I I I I

I Figure Z.11

HRRU Lens Positioning

I

I

I

58

I

CHAPTER 3 MAINTENANCE

I

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I 3.1 ROUTINE BASIC MAINTENANCE

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I

* + 1. Rot ary pump belt tension
    2. Changing the tu rbo pump oil
  1. COLUMN SERVICING

I

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I

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I

I 59

* 1. ROUTINE BASIC MAINTENANCE

I

3.1.l ROTARY PUMP OIL LEVEL

Check the oil level in the sight glass on the pump. The minimum o il level is the lower edge of the sight glass. The maxi mum level is 25mm below the top of the glass. When necessary top up with oil of the t ype specified for the particular pump i n use. (i.e. Edwa rds no 15 for Edwards pump or Alcatel VPl for Alcatel pumps).

I

I

* + 1. AIR ADMITTANCE DRIER ASSEMBLY

I

If the air drier is allowed to become inef fective the pump down t ime of the 5200 will become longer than normal.

I

The assembly is moun ted on the rear panel of t he plinth. The colour of the desiccan t in the assembly should be checked daily and if it shows signs of becoming saturated i.e. turning from bl ue to pink or whi te, i t should be replaced or react ivated. To renew the desiccant:

I

* + - 1. Uncli p the drier from the rear of the plinth.

I

* + - 1. Unscrew the large knur led retaining r ing from one end of the assembly and remove the end cap. Remove the filter washer beneath it. The desiccant can now be poured out and either dried or d iscarded. Remove the rema ining filter washer and the perfora ted met al support.
      2. Clean the parts by washing in a suit able solvent, e.g.

liquid detergent, af ter which each part must be thoroughly rinsed and dr ied.

I

* + - 1. Replace the perforated metal support wi th the concave side facing away from where the desiccan t will be. Cover wi th two filter washers (shiny side away from the desiccant). Fill the assembl y wi th new or react ivated desiccant. Fit a f ilter washer wi th the shiny side towards the desiccant. Fi t the end cap and knurled clamp r in g.

•

I

* + - 1. Refi t the assembly to the reer panel of the plin th.

I

* 1. 6-MONTHLY MAINTENANCE

3.2.1 CHANGING Tl-£ ROTARY PUMP OIL

I

It is recommended that the rotary pump oil is chan ged after the first 100 hours operation and thereaf ter at 6-monthl y

I

ll.

intervals, wi th in termediate checks on the o il level.

To change the oil:

1. Select CHAMBER VACUUM ven t and wa it for the rotary pump to stop. Unplug cable nu mber 6 to remove tur bo pump power.
2. Place a conta iner of not less than 2.5 l itres capacity under the oil dra i n plug at the bottom of the pump. Remove the pl ug and drain the oil.

c. Remove the two screws holding the vacuum hose rnanifold to the rotary pump. Break the vacuum seal by caref ull y moving the hose sideways. Remove the pipe manifold, 0

I

I 60

ring carrier and 0 ring. W ith the rot ary pump outlet partl y sealed (e.g. by the thumb) select CHAMBER pump. The rot ary pu mp will start and eject the rema ining oil.

I

Cont inue unt il the pump is empt y.

I

**WARNING:** Ouring this process o il will be ejected from the pump wi th great force. A void risk of inhalat ion or **eye contami nation.**

I

1. Pour a small quantit y (e.g. 0.75 li t res) of clean oil down the rot ary pump inlet. Allow th is oil to be pumped away before switchi ng of f the pump by select ing CHAMBER ven t.

I

1. Replace the drain plug and remove the fi ller plug at the top of the pump. Refill the pu m p wi th the oil recommended i n the pump manufacturers handbook.

I

1. Replace the filler plug and run the pump for about 30 seconds wi th the i nlet open to a i r. Refit the 0 ring carr ier, 0 r ing, pump hose mani fold clamp ring and 2 **screws.**

I

1. Connect the turbo pum p cable, num ber 6, and pum p down the system.

I **3.2.2 ROTARY PUMP BELT TENSION**

The direct drive rotary pu mp norma lly supplied does not have

a dri ve bel t. If a bel t drive pump has been fitted the correct bel t tension should be checked accord ing to the pump

I

.. **manufacturers instructions.**

•

**3.2.3 CHANGING Tl-E TURBO PUMP Oll..**

The turbomolecular pump bear ing oii should be changed every

6 months using the inst ruct ions supplied by the pump

I

manufacturer. It is very strongly recom mended that this wor k is carried out by a Cambridge approved service

**engineer.**

I 3.3 **COLUMN SERVICING**

The periods between cleaning will depend on the frequency of use,

**type of specimens and environmental condit ions, etc. As a general**

I

rule, i f the requ ired performance can be achieved then leave well alone. Only if the resolu tion deteriora tes and cannot be improved by adjustment is cleaning necessary. The degree of cleaning needed can

I only be determined by inspect ing the column components.

Rou tine cleaning consists of clean ing the grid and anode and inserti ng

clean apertures. If this does not restore the per f ormance, then the whole column must be d isman tled and cleaned. The extent of this depends on the severity of con tamina t ion, which can only be found by inspecting the column as it is dismant led.

**l**

**3.3.l CLEANING RECOMMENDATIONS**

**A ll swabs should be made from clean, absorbent, lint f ree**

mater ial whi ch will leave no dust or part icles on the cleaned

I

I 61

**surfaces. A low power binocular microscope is useful to** enable dust part icles to be seen. All cleaned components must be kept covered to protect them from dust in the at mosphere. Great care must be taken when handling any part of the column since a ll parts are machi ned t o close tolerance. Nylon gloves must be worn when handling all po!epieces, gun parts and other components exposed to the electron beam.

I

I

I

An aerosol can of freon or similar compressed gas is very usef ul for blowing the dust of f each component as it is replaced in the column. Commercial compressed air should **not be used as i t conta ins oil vapour.**

I

**WARNING: DO NOT ALLOW ANY LIQUID TO COME INTO CONTACT WITH THE GUN CERAMIC.** IT IS **ESSENTIAL TO AVOID MAGf\ETISING ANY PART OF THE COLUMN. THE STEEL USED FOR COMPONENTS IN THE MAGf\ETIC CIRCUITS (I.E. POLEPIECES) IS OF A VERY SOFT TYPE ANO WILL RUST VERY QUICKLY IF LEFT IN THE ATMOSPHERE. WHERE POSSIBLE THE**

I

I

**CCLUMN SHOULD BE KEPT UNDER VACUUM.**

I a. STEEL ANO STAINLESS

HIDUR AL COMPONENTS.

look ing metal.)

I

STl::EL, COPPER AND

(Hidural is the copper y

In normal cleaning, wash in a 10% solution of quadralene in water, followed by dist illed wa ter. Rinse wi th propanol or other suitable solvent and dry wi th a hot a i r blower. In the case of severe contami nat ion the init ia l clean ing in quadralene should t ake place in an ultrasonic cleaner for at least 20 m inutes. Components which are severel y cont amina ted may be cleaned wi th Hyprez (see next section).

I

**i**

1. ALUMINIUM COMPONENTS.

I

AND AL UMINIUM ALLOY

These components may be cleaned wi th Hyprez diamond compound grade l-W-47 or, in t he case of severe contamina t ion, grade 4-W-47. Wash of f all Hyprez wi th Arklone, methanol or pro pane!, preferably in an ul trasonic cleaner, and dry of f using a hot air blower.

I

I

DO NOT USE: QUADRALENE ON A NY COMPONENTS CONTAINING ALUMINIUM.

I

1. MOLYDE NUM SPRA Y APERTURES AND PLATINUM FINAL APERTURES.

l These may be flashed by electricall y heat ing the **apertures in a molybdenum or platinum boat, in a vacuum,** to whi te heat. They should be held at this temperature for a few minu tes before be ing allowed to cool. Al terna tively, spray apert ures can be cleaned using method B.

I

I 62

1. MU METAL

I These components should not be cleaned except for the

removal of dust. It is important that the metal is not strained or dropped as this will reduce i ts ef fect iveness as a magnetic screen.

I

1. 0 RINGS

I 0 rings ma y be cleaned wi th, but not soaked i n, A rklone, methanol or propanol. The use of 0 ring grease is not

recommended on any 0 rings, but a small amount may be used, if necessar y, on movi ng seals e.g. in the specimen stage and apert ure changer m icrometers. The grease must be applied wi th a lint free t issue to avoid conta m ination with natural oils, usi ng only enough grease to just put a shine on the O r ing. Apiezon L grease is recommended.

I

I

I f . 0 RING GROOVES AND FACES

Very fine abrasi ve paper may be used sparingly to remove

any scratches. Wash any surfaces treated in this way in the appropria te solven ts for the parti cular materia l.

I

WARNING: ANY COMPONENT WITH 0 RING GROOVES ANO/OR MATING SURFACES, ANO WHICH IS TO BE ULTRASONICALLY CLEANED, SHOULD BE PLACED IN THE CLEANER TANK IN SUCH A WAY THAT THE GROOVE OR FACE DOES NOT TOUCH THE WALLS OF THE TANK, OR ANY OTHER COMPON::NTS.

I

I

.. }.3.2 ROUTINE COLUMN CLEANING (fig 3.2)

The numbers quo ted thus (23) refer to the ident ifica tion markers in figure 3.2.

I WARNING: Certa in screws (items B, D, E, H, I and J in

f igure 3.6) in the column are connected with the electron

opt ical alignment of the column. If these screws are touched, column alignment wi ll be af f ected, leading to time consu m ing realignmen t. lndiscri mate column disman tli ng should be avoided.

I

l

The first stage of column clean ing consists of clean ing the gun componen ts and the f inal apertures. The method of doing this is:

I a. Vent the column 1md chamber to air.

1. Open the gun.
2. Loosen the three filament assembl y clamp screws (1) and remove the filament assembly (2).

t

1. Lif t out the anode (3). Take care, the anode is a very good fit on the top of the alignment coils (4).

········---------

I

I 63

1. Remove the four M 3 screws hold ing the aperture changer

(15) i nto the colu mn, and remove t his assem bl y from the column.

f , Close the gun while the components removed are cleaned. Take the filament assembl y, anode and aperture changer to a clean area for cleaning.

I

1. Loosen the two screws (8) clamping the filament holder into the grid and separate the two componen ts. (f igure 3.3).
2. Loosen the four screws (C) hold ing the filamen t into its carr ier and remove the f ila men t (figure 3.3)

I i. Remove the

.

three

screws holdin g the aperture clamp

pla te from the apert ure blade. Lif t off the cla mp pla te

and remove the apertures from the carrier (f igure 3.4).

I j. Clean the grid and anode by method A above.

k . Clean the aper ture blade and apert ure clamp pla te by met hod B above.

I

1. Clean the apertures by method C, or use new ones.
2. Replace the apertures in the aperture blade, fit the clamp plate and screws.

**Note:** The apertures ha ve one f lat side, the other side being f unnel shaped. The apertu res m ust be mounted in t he blade wi th the flat side upwards when the apert ure chan ger is moun ted in the column. Clean the 0 ring on the aper ture changer, put i t i n the colu mn and replace the four screws.

•

1. Put the anode on top of the alignment coil mak in g sure that it is correctly seated onto i ts locat ion boss. The anode should sit level on the align ment co il and be free to **rotate, but not be loose.**

I

I

1. f f necessar y change the f ilament, cen tre i t i n the gr id and replace the assembly in the gun (as det a iled i n section 3.3.7).

I

1. Pump down the column and cha m ber and obt ain a picture as deta iled i n chapters 1 and 2.
   * 1. **BASIC COLUMN DISMANTLING, CLEANING AND REASSEMBLY (fig 3.2)**

If the rout ine colu mn clean ing of section 3.3.2 is not sufficient, the second stage of colu mn clean ing is detailed below.

* + - 1. R.emove and clean the filamen t assem bl y , gr id and final apertures as deta iled i n 3.3.2.

t

* + - 1. Moun ted in the top of the anode section, under the anode, is the gun align ment coil (4). Remo ve the three M4

I

I 64

screws holdi ng i t *dovm.* Usi ng the special tool, caref u lly li f t the coil assembly out of the anode section VERTICA LLY. (It has an 0 Ring seal on its lower end). The assembly is wired to the elect ronics by a cable entering the back of the anode section. As the assembl y is Iif ted, ease the cable into the anode section. As soon as the socket connecting the cable to the co il is visi ble, disconnect it. Leave the cable laying in the anode section.

I

I

I

* + - 1. Under the gun alignment coil is the anti contaminat ion collar ( 5 and 6). Using a long hex socket dr iver, remove the three M3 screws holding i t down. Using the tool prov ided lif t the assembly out of the anode section. Invert the assem bly and remove the 0 ring. Remove the two M Z screws and separa te the inner (5) and outer (6) sections. Remove the two M2 screws from the top of the inner section and lif t of f the top "aperture".

I

I

I

* + - 1. Protrud ing from the top of the lens is the lens liner tube (7). Using the special tool lif t out the liner tube. Remove the top apert ure clam p and top aper ture (8). R emove the bo ttom apert ure clamp and aperture (9). Close the gun.

**l**

* + - 1. Caref ully clean a ll componen ts using cleaning recommendation A or B, ensur ing that a ll traces of **contamina t ion and discoloura tion are removed from all** components. This can be a t ime consu ming task, bu t it m ust be done very caref ully.

I

I

f . Wash all parts in Ark lone, methanol or ethanol in an ul trasonic cleaner. Visua lly check that a ll t races of cleaning ma teri als are removed. Wash again in clean **solvents.. Now wash again in more clean solvent.**

•

1. Put a spray aper ture in the top of the liner tu be (the end with the pumping holes) and replace top aperture clamp. Fit the other spray aperture and the long nosed clamp (10) in the bottom of the liner t ube. Store the assembl y i n a

I

I clean plast ic bag or wrapped in clean tissue.

1. Fit the top "aperture" to the ant i contam ination assembly

**i nner section wi th two M2 screws. Fi t the inner section**

I

(5) i n the outer section (6) wi th two M2 screws. Clean the 0 ring and ref i t to the bottom of the assembl y. Store the assembly in a clean environ men t.

'

1. Check the bore of the gun alignmen t coils (4) are clean. Clean and fit the two 0 rings.

L j. Unwra p the lens liner tube and replace it in the column. Check tha t i t is f ully down in the lens. (The top two pu mping holes should be just above the lens top pla te with the lower pu mping holes not visi ble.

k . Check the 0 r ing in the bottom of the ant i contaminat ion assem bl y. Fit the three M4 screws into the bottom f lange and, usi ng the speci al tool, caref ully lower the assembl y

I

65

I

into the column. Rota te the assembly un t il the screws are felt to line up wi th thei r holes. Tighten the screws.

I

1. Check the gun align coil and its two 0 r i n gs for dust. Connect cable 87 to the coil. Fit the three 4 screws into the flange. Using the special tool, caref ully lower the coil VER TICALLY in to the anode sect ion. (Remember there is an 0 ring on the bottom of the coil which must enter in to the top of the ant i con tamination assembl y ). Rotate the assembly unt il the screws are f elt to line up. T igh ten the screws.

I

I

1. Refit the f ilament assembl y, grid and aperture changer, as detailed in section 3.3.2.

I

I

**3.3.4**

I

**L** I I

I I I I I

L

I I

1. Pu mp down the column and cham ber. Obt ain an image as described in chapters land 2.

**COMPLETE COLUMN BREAKDOWN (fig** 3.2 **and fig 3.6)**

The nu mbers ref er to f igure 3.2, the let ters to figure 3.6)

If the cleaning deta iled in section 3.3.3 is insuf f icient then a complete column breakdown is required.

1. Remove the gun hinge pi n and earth strap. Remo ve the gun from the top of the colu mn.
2. Remove the four M4 screws hold ing the top of the pu mping pi pe to the anode section. Push the pipe backwards so tha t i t just clears the anode section when i t is lif ted off . If you have an ion pump fitted, remove the four 6-32 UNC screws holding the magnet to the pump body. Remove the magnet. Note that these screws are a d i f f erent size from all others on t he SZOO and must not be i n terchanged wi th any other screws from the machi ne.

**c. Remove the filament assembly, anode, gun align coil ,** final aperture changer, anticon tam ina tion assembly and lens liner tube as deta iled in sections 3.3.2 and 3.3.3.

1. Hal f way down the colum n is a f l at 25m m wide dark coloured met al band secured by a single screw (16). Loosen (do not remove) the screw, open the band slightly and slide it up the column a litt le way. This w ill reveal si x M4 caphead screws (A). Remove these using the hexkey provided. . If an ion pump is fi t ted you must support the anode section when removing the last of these screws. Lif t off the anode section.
2. Lif t of f the top trim ring from the mumetel shield. Remove the column isola t ion valve i f fit ted. Remove the vert ical mumetel shield.

**f . Disconnect the si x "in-linen connectors at the rear of the** condenser lens. Check that the six M4 screws (!) housed in the recesses round the bottom of the condenser lens are t igh t. Loosen (do not remove) the four M3 grub screws

(H) that are housed hor i zon t ally in the side of the large f lan ge at t he bot tom of t he condenser lens. R emove the

I

66

I

six M4 screws (C) (the outer ri n g, not the ones in the recesses) secur ing the condenser lens and I i f t of f the lens. Store it laying on i ts side, stand ing it on end may damage the sealing faces.

I

* 1. Unscrew the 3 screws (13) and remove the scan coil assembly. (The screws are deeply recessed into the scan coil pot). Remove the cable clamp from the scan coil pot. Unplug the connectors from the scan coil PCB. Remove the 2 screws which hold the scan coil onto the scan coil pot. Separate the two components. Remove the 0 r ing clamp plate from the top of the scan coil. Remove the top and bot tom 0 rings.

I

* 1. Unscrew the 4 fixing screws (F) and li f t off the final lens.

I

**Note:** The final Jens f i xing screws are the four situa ted on the outer ring on the Jens fl ange. The screws on the inner r ing hold the two par ts of t he final lens t ogether. If they are loosened the lens alignmen t ma y be dist ur bed **requir ing ex tensi ve column alignment.**

I

* 1. Clean the scan coil and the scan coil pot usi ng cleaning recom mendation B.

**l**

j. Clean the top and bot t om faces of the condenser lens with solvent. Do not remove t he top and bottom end plates of the lens if it is absolu tel y necessar y i.e. to repa i r a vacuu m leak in the 0 r ings under the lens pla tes. If the pla tes are removed a complete colum n alignment will be requ ired.

I

k. Lay the final lens on the bench wi th the end that is nor ma ll y in the cha mber uppermost. Remove the lens protect ion pla te. Inspect the bor e of the lens. It may, i f **necessary, be wi ped wi th a clean, lint free t issue soaked** in solvent.

I

Only if the tens bore is severely cont aminated may i t be po lished wi th hyprez grade 1-W-47 on a piece of sof t balsa wood or other sof t lappi ng stick. All traces of cleaning compound must be removed usi ng a solven t. Take great care not to scratch the lens bore or the lens f ace over an area of about 2cm radius abou t the bore.

I

IT IS **STRONGLY RECOMMENDED THAT POLISHING Tl-£ FINAL LENS BORE IS ONLY DONE BY AN ENGl1'£ER WHO HAS BEEN TRAINED AT CAMBRIDGE.**

If the lens bore is so badly con tamina ted tha t the upper and lower polepieces of the lens must be separated to allow ef ficient cleaning, the procedure is now given. It requires t hat the ent ire column be realigned af ter assembly, the method for this bein g given in sect ion 3.3.s.·



i. Remove the 4 screws (E) holdin g the polepieces together. Stand t he lens wi th the lens bore uppermost and lif t off t he lens plate vert ica ll y t ak ing care not to twist or rock

I

67

**the polepieces i n a manner whi ch might disturb the four**

I

a lignmen t blocks.

**DO NOT DISTURB TI-E FOUR ALIGNMENT BLOCKS WHID-t LOCATE Tl-£ LENS PLATE ONTO Tl-£ BODY. Tl-EY CAN ONLY BE RESET IN CAMBRIDGE.**

I

1. Clean the lens polepiece wi th hyprez l-W-47 as described

I above.

1. Reassemble the final lens and replace it on the column.

Remember to check the 0 ring.

I

1. Fi t the 0 r ings (top and bottom) and 0 r ing clamp to the scan co il. Fi t the scan coil pot on to the scan coil (wit h an 0 ring between them ), check ing that the locat ion pins in the i n terface loca te correct ly. Connect the cables to the scan coil PCB, fi t the cable clamp, put the scan coil assembly i n the fina l lens (check t he location pins) and screw i t down. Route the cable through the column wall.

I

I

1. Check the 0 ring on top of the scan coil pot, put the

I **condenser lens on and screw i t down.**

1. Fit the mu metal shield and top trim r ing.
2. Fit the anode section and screw i t down.
3. Fit the gun pumping t ube. (Remember the 0 r ing.)

I t. Fit the ion pum p magnet and column isolation val ve (if appl ica ble).

I

1. Fit the gun. Replace the gun hinge pin AND THE EARTH

I

STRAP.

1. Fit the rest of the column com ponents as descr ibed in section 3.3.2 and 3.3.3.

I

I

**3.3.5**

1. Check the colu mn align men t and adjust if necessary (see 3.3.8).

**CLEANING Tl-£ SPECIMEN CHAMBER.**

Although i t is possible to clean the cha m ber wi th the column intact, i t is easier to do so wi th the column removed. I t is therefore recommended that the cha mber is cleaned whenever the colu mn is removed for servicing.

1. Remove the speci men stage.
2. Unscrew the four M4 screws and remove the collector system moun ting plate from the rear of the cham ber.
3. Clean a ll interior faces of the chamber wi th a l int free t issue soak ed in A rklone, methanol or ethanol. Af ter cleaning, dry the inter ior of the chamber wi th a hot air blower.

68

1. If the con tami na tion is severe, a tl opt ions fitted to the chamber should be removed and cleaned separately. When replacing the opt ions, clean all O rings and check them for damage.
2. Refit the collector system and specimen stage.
   * 1. **REPLACING TI-IE SCINTILLATOR AND LIGHT GUIDE (fig J.5) and (fig 3.5a)**
        1. Unscrew the 4 screws and remove the collec tor system mou nt ing pla te f rom the rear of the chamber.
        2. Slide back the two protective sleeves A and B. Loosen the th ree screws C, D and E on the back plate and remove the three wires from the sockets.
        3. Loosen the ny Ion screw F and remove the ligh tgu ide assembly from the back plate.
        4. Remove the fron t mesh G and focusing apertu re H from the end of the collector cage. Loosen screw I and carefully slide the ligh tgu ide from the cage assembly. Take great care not to damage the w i re connected to the brass r ing on the end of the scint illa tor. If the wire breaks away from the brass r i n g i t cannot be resoldered as this damages the l igh tgu ide.
        5. Clean a ll parts of the collec tor system (except the ligh tgu ide) wi th Ark lone, methanol or propanol. Insert a new ligh t gu ide into the collector cage, tak ing care not to touch the scint illa tor w ith the f ingers (or any th ing else).

f . F i t the f ron t mesh and f ocusing aperture. Adjust the posi t ion of the collector cage assembly on the ligh tgu ide so tha t dimension J is lZmm as shown. Tighten screw I.

1. Fit the lightgu ide assembly in to the backpla te and tigh ten

**screw F.**



1. Reconnec t the three leads, no t forgett ing to fi t the

**protect ive covers.**

1. Refit the collector back plate to the chamber.
   * 1. **CHANGING THE FILAMENT (TIJNGSTEN GUN)**

**(figure 3.3)**



For deta ils of the LaB6 cathode change see section 4.2

* + - 1. Ven t the colu mn b . Open the gu n

*c .* Loosen the three fila men t assem bly cla mp screws (A) and remove the fila men t assembly. Close the gu n.

1. If a spare filament assem bly is available, fit i t. ff not rep lace the fi lament as follows.

.·--····----·-------

I

69

I

1. Loosen the filament holder cl amp screws (B) and remove the filament holder from the gr i d.

I

f. Loosen the fila men t alignment screws (C) and remove the filament.

I g. Clean the grid, anode and filament holder as requi red.

1. Refi t the filament holder into the grid and tighten the clamp screws (B).

I

1. Put a new filamen t into the holder and gen tly tighten the

I filament alignment screws (C).

j. Turn the assembly over, look at t he filamen t through the

grid hole and move the f ilament to t he cen tre of the gr id usi ng the filament alignment screws (C). For the best **instrument per formance this must be done as accurately** as possi b le. A low power microscope or a wat chmakers eyepiece is very usef ul i n allowi ng the alignment to be **seen better.**

I

I

1. Usi ng the three hei ght setti ng screws (D), set the filament to be O.Smm behind the fron t face of the filament.

**l**

1. Refi t the fila ment assembly to the column, pump down

I and obta in a pict ure as det a iled in chapters 1 and 2.

* + 1. ALIGNING Tl-£ COLUMN.

(figure 3.6)

I

Var ious stages of column align ment ma y be needed, as ind ica ted by the fo!lowi ng criter ia.

* + - 1. If the Cl/CZ lens assembly has not been li f ted of f the fi nal lens (C3), and provided the four sets of column

clam pi ng screws A, C,

•

I

E and I (6 in each set) and the

**three sets of column alignment screws B, D, G and H (4 i n** each set) have all rema ined un touched, and therefore are not loose, then no alignment is necessar y. It may be a good idea to check the alignmen t (steps 70 onward).

I b. If only the 6 column to f inal lens clam pi ng screws (C) and

the 4 column to final lens clampi ng screws (F) have been

loosened, then steps 7 to 37 and steps 70 onward should be

I

**done.**

1. If any of the other alignmen t or cl ampi ng screws have been loosened then the complete procedure wi ll be requ ired.

Note: Always leave all alignment screws tight at t he end of each stage of a lignment.

Tools requ ired

I a. 12 Ml.5 hexagon wrenches to fit M3 grub screws

* 1. A f elt t ip pen which can wr i te clearly on the displa y
  2. Short ended M3 hexa gon wrench part no 716727
  3. Ball ended hexagon dr iver part no 429008

I

I 70

I Other requ irements

A well ma inta ined specimen stage capable of movi n g in l

**micron i ncrements.**

I A filament which is well centred in the gr id.

Shif t coils (cable 198 on the EO PCB) unplugged.

I

A digital mul t imeter, set to read vol ts, connected across testpoints TP15 and TP16 on the EO board.

I Initi al Screw Adjustments

**CAUTION** Do not perform steps 1 and 2 unless Cl and C2 poleplates have been removed or loosened.

I

* l Loosen the 6 vert ical M3 cap head screws (J) accessed through the holes in the anode section mount ing flange.

I

1. Loosen the 6 vert ical M4 cap head screws (A) on the

**l** anode flange usi n g the short hex k ey.

1. Release the 6 vert ical M4 cap head screws (C) next

to the slots and the 6 vert i cal M4 cap head screws

I

(f) i n the slots in Cl/C2 body.

4 Set the 4 hori zontal M 3 grub screws (H) i n the top of C3 to cen tre tra vel (not the ones in the clear ance holes).

**CAUTION** Do not per form steps 5 and 6 unless Cl or C2 pole plates have been removed or loosened.

5 Set the 4 hor i zontal M3 grub screws (D) down the clearance holes i n the top of C3 to centre tra vel.

I 6 Set the 4 hori zontal M3 gr ub screws (B) i n the

tapped holes in the top of Cl/2 to centre travel.

I Start of alignment procedure

7 Set the Optibea m selector switch (the small OIL switch) on the EO PCB so that the poi nter is

towards the A on the sw i t ch. This sets the optibeam system to the align mode.

1. Set C3 reversing switch (on the EO board) to normal.

I

1. Set all 4 gun align controls to centre.
2. Turn fine acceler ation voltage clockwise.
3. Select 20 KV
4. Adjust the fine resol u t ion control so that t he DVM on TP15 and TP16 reads 300 mV.
5. Set Resol ution coarse to 8.

I

71

1. If you have beam down the column set the filament

I current to first peak. If not, go to step 17.

1. Adjust the speci men to 10mm work ing distance and 45 degree t ilt.

I

1. Go to step 25.

I 17 If no beam is visi ble select emi ssion image.

18 Adjust aper ture centring and gun align to obtain a

beam. If a beam cannot be found go to step 22.

I

19 R eset gun align as near centre of travel as possible to still ma i n ta in a beam.

I 20 Adjust fina l apertu re.

21 Go to step 25.

I

22 Reset gun align to centre tra vel

23 Adjust Cl polepla te screws (8) to find the beam

1. Go to step 25

I Findi ng C3 axis

During these proced ures i t will help if you pu t a small

label on the hex keys used to adjust screws (D) so they are not con fused wi th those i n screws (H).

I

1. Usi ng focus wobble, centre the f inal aperture.

I 26 Centre an easi ly recognisable feat ure on the screen. Pick something that can be recogn ised at a magn ifica t ion of lOOX and has 1 m icron detail on i t at hi gh magnifications.

I

27 Focus accura tel y com ing from the ant iclockwise end

I of the med ium focus control.

28 Centre the aperture usi ng focus wobble.

I

1. Repea t from 26 if the reference f eat ure is no longer visi ble.
2. Mark the posi tion of the reference feature on the screen. Reverse C3 current usi ng the reversal switch on the ED board .

I

.31 Mark the new posi t ion of the feature on the screen.

If i t has mo ved less than 2 m icron go to 35.

32 Usi ng the stage, move the f eature ha lf wa y back to i ts or i ginal posi tion.

I

I 72

33 Select focus wobble. Adjust the colum n alignment

I

screws (H) and the aperture posit ion so that you have sim ul taneousl y

1. zero i mage shif t with focus wobble and

I

1. the ref erence f eature in the centre of the

**screen**

I 34 Repeat from step 30 un t il condit i on in 31 is met.

35 Switch the C3 current back to normal (not

I

reversed).

36 Do not move the aperture or stage from now on. f f Cl and CZ po lepla te clampi ng has been loosened, go

I t o step 38.

1. If Cl and C 2 poleplates have remained clamped,

I

align ment is com plete. Check al ignm ent as i n step 70 onward.

Adjust ing C2 axis to coincide with C3 axis.

**l**

1. Set lower gun al ign kno bs centr al. Adjust upper gun align knobs for max br igh t ness.
2. Set Resolution fine so DVM on C 1 reads about SOOmV.
3. Starting wi th C 2 high, reduce the resolution coarse control adjust ing CZ poleplate screws (D) to keep the beam going down the column. If at any time you

I

; get uncon trolla ble beam cut off go t o 49.

41 At a resolution of 4 reset u pper and lower gun align

controls for maximum brightness.

I 42 Focus C3

1. Adjust C2 polepla te (D) to achieve zero shif t wi th focus wobble.

I

1. Set resolution coarse to 9.

I 45 R efocus C3

1. Adjust co lumn adjusti ng screws (H) for zero shif t wi th focus wo bble.
2. Set resolution coarse to 4.
3. Repeat from step 42. Af ter the third t i me through go to 49.

Getting Cl ont o the axis of C2 and C3.

1. Set to gun ali qn mode.

- ------------- - - - - --- -,----------- --"---·--- ----

I

I 73

1. Set resolu t ion coarse to 4.

I

1. Set resolut ion fine so DV M reads 800 m V.
2. Use Shif t to centralise source image in aperture image.

I

1. Use Tilt to centre gu n align image.

I

1. Red uce Cl curren t (resolut ion fine), adjusting Cl polep lates (B) to keep the aperture like dark image from encroaching on the bright source image. The adjustment will at the same t ime recentre the gun align image on the screen, but:

I

I

1. If further adjust men t is needed use the t il t con trols, these will have ai;i increasi ng ef f ect a'i the lens **currents are lowered.**

I

1. Con ti nue adjustments unt il the source image collapses and expands as you go through the final aperture wi th no cutof fs.

**l**

1. Stayi ng i n the gun align mode, switch the lenses back to opt ibeam.

I

1. Adjust resolut ion coarse. If cut of f occurs at low resolu tion numbers, adjust shif t con trols to cen tralise the aperture ima ge and the til t controls to centre the bri ght part of the emission profile in the aperture.

I

* 59 Select align ment mode aga i n.

60 Repeat 50 to 58 inclusi ve.

1. Repeat 39 to 48 i ncl usi ve.
2. Set resolut ion coarse t o 4 and fine so the DVM reads 800 mV.
3. Obt ain an image of an interesting feature i n the centre of the screen at lOK X.
4. Swing resolution fine control over i ts f ull range. If

the featu re moves more than 2 microns go to 68.

1. Repeat 64 until the cond i tion is met.
2. Repeat 63 t o 65.
3. Test column alignmen t as in 70 onward.
4. Focus C3. Move features half way back t o the centre using Cl poleplate adjustmen t screws (B).
5. Repeat from 63.

I 74

Testing column alignmen t

I 70 Check that C3 reversal switch is set to normal and

the alignment swi t ch is set to opt ibeam.

I 71 Set resolution coarse to 11.

72 Obta in an image wi t h a recognisable f eature in the

I centre of the screen at lOKX.

1. Adjust the reso lution cont rols. The f eature must

stay on the screen at all settin gs of the resolut ion controls.

I

1. Repeat 71 to 73 at ot her KV settings. The feat ure

I should stay on screen at all KV settings.

**Note:** There will be some i mage shif t as KV is changed

so the f eature will have to be recentred on the display at each KV.

I

1. If column alignmen t test is met go to 79.

I 76 If specification is not met try step 58.

1. If i t is still not met tr y 49 to 58.

I

1. If i t is st ill not met st art aga in.

I Locking the colum n together

1. Obta in an image of a recognisable f eature at lOKX

at a resolu tion of 5.

I 80 Caref ully t ighten all four rings (A, C, F and J) of 6

clamping screws a li t t le at a time in an or der such tha t the image does not shi f t.

I

81 Cen tre the final aper ture using focus wobble.

I 82 Check column alignment using steps 70 onward.

83 Check that the lens off set controls are correctly

set. Set opt ibeam to align wi th the DIL switch on the EO PCB. Set resolution coarse to 1 and the fine control f ully clockwise. Select OPTIBE.l\M nor mal. Adjust RVS on the EO PCB such that the image of the aperture is at its sma llest (the lens crossover is in the aperture). Now select aperture not normal (switch released) and adjust RV7 so the image of the aperture is aga in at i ts smallest. Select opt ibeam normal wi th t he DIL swit ch on t he EO PCB.

I

I

I

I

I 75

3.4 REPLACING THE SWJJ\G DOOR STAGE (fig 3.5) and (fig 3.5a)

I 1. Obta in the swing door stage and the 4 secur ing screws for the

h inge bloc k.

I

1. **Vent the charnber** and **remove whatever is mounted on the front**

of i t.

I

1. Set the stage Z con trol to i ts lowest setting. Set the Y control to a low read ing ( 25mm ) and the X con trol to cen tre (50mm ).
2. Off er up the stage to the chamber, engage the h inge block loca t ion pin in the slot in the cha m ber, and attach the block loosely to the chamber w i th the fou r M 5 screws (see f igure 3.5). Engage the stage door f astener wi th the hook on the side of the

I

I cha mber. Ti gh ten the screws i'n the h inge block .

1. Check that as the stage door is opened and closed the loca tion p in on the r igh t side of the door fi ts smoothly into the slot i n

I

the cha mber. If i t does not slacken the rear facing grub screw in the rear of the hinge and adjust the righ t f acing cap head screw at the back of the hi nge clockwise to ra ise the door, ant iclockwise to lower i t. Lock the grub screw.

6. Slacken the four h inge block· screws ha lf a tu rn. Pu mp down the cha mber. Tigh ten the h inge block secur ing screws.

I

3.5 Changing the Anode

The acce lera tion vol t age range is split i n to two, above 4K V and below 3K V. Th is change is selec ted by the ACCELER ATION VOLTAGE High swi tch. To ach ieve a better gun geome try and br ightness and hence be t ter instru men t per f ormance the anode shou ld be li f ted

I

I towards the gr i d when the low KV r ange is selec ted. To do this

1. Adm i t a i r to the gu n. Open the gu n.
2. Lif t ou t the anode.

I

1. Fi t the anode spacer on the top of the gun align coils. Take care, this is a h igh precision fi t.
2. F i t the anode back on top of the spacer. Th is is also a good fit.

I

1. Select !\_ow ACCELER ATION VO!\_ TAG E range (see 2.2.2).
2. Close the gu n, pu mp down and obta i n an image.

The 5200 should not be used on the High ACCLER A TION VOLT AGE ran ge wi th the anode spacer f i tted.

I

3.6 Looking for Vacuum Leaks A few simple ru les

l. Before look ing for a vacuu m leak give the v acuu m sy stem t ime to pu mp. If you have just cha nged a specimen i n a very hu m id a tmosphere the pu mpdown may t ak e longer. If the specimen is we t i t may take several m inu tes (up to 1 hou r wi th a very large, very wet specimen has been known.) If the stage has been lef t open for lon g per iods i t will t ake longer to pu m p. If the colum n or chamber have been washed w i th solvents then i t may ta ke **severa l hours to achieve a good vacuum.**

l

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2. Vacuum leaks rarely ha ppen, they are of ten caused. lf you have just done anything to the colu mn or chamber then that is the most l ike ly cause of the leak. If the speci men has just been changed, check the stage door 0 r ing. Sim ilarly if the filamen t has been changed check the gun 0 ri ng.

1. The most frequent cause of leaks is dust or fibres on 0 rings. 0 rings may be cleaned with a fluf f free tissue dampened with Arklone, m ethanol or ethanol. 0 ri ng grease should only be used on sliding seals in the apert ure changer and specimen stage. Grease traps fibres and may cause leaks.

I

1. Do not use any metal tools to remove 0 rings from their grooves. A small scratch in the bottom of a groove causes a bi g leak.

I

1. lf t he pump down is slow, check the air adm i ttance dr ier and renew the desiccan t before look ing for a leak.

I Detect ing a leak.

The first requiremen t is a method of measuri ng the vacuu m. Some met hods, starting from the sim plest, are

**l**

l. Use the buil t in vacuum ind icator, th is is not reall y sensi tive

I enough for leak hunting.

1. Add a mor e sensit ive meter to the internal vacuu m gauge. This

can be done in two wa ys.

I

* 1. To measure the cha m ber pressure usi ng the buil t in Penning gauge, connect a vol tmeter from the ju nct ion of R 2 and R 3 on t he vac aux PCB 852628 to ground.

I

b. To measure t he vacuu m more accura tely i n the colum n when an i on pu mp is fitted, connect a voltmeter from test po in t A TE 3/3 on the ion pum p control PCB 852626 to ground.

I

1. A still better method is to disconnect the Penni ng gauge from t he vac i n terlock PCB and connect to a commercially ava ilable Penning gauge box, e.g. a Penni ng B gauge box ava ilable from Edwards High Vacuu m Lt d.

I

4. The best , and most expensi ve method is to fi t a com mercial leak detector system to the chamber, e.g. a mass spectrometer. This only proves to be requ ired i n very rare cases.

The second thing you need is to find the leak. This is done by pu tt ing some liquid or gas onto the leak. The liquid or gas used must do two things. It must quickly find i ts way through the leak and i t must cause a reaction on the vacuum gauge.

If using a mass spectrometer leak detector the normal gas to

I

**use is heli um.**

I

If you are usi ng the i n ternal penni ng then the normal leak detect ing (trichlorotrif louroethane) and Freon. chloroflouroet hanes, sold as dusters guns are also good for leak de tect ing.

I

I

77

gauge as a leak detector fluids include A rklone **Aerosal cans of various** or propellan ts for spray

Met hod of f ind ing the leak

I L Set up the vacuu m measu ring equ ipmen t

Get some leak detect ing flu id

2.

I

3. Put a small amount of leak detect ing fluid on a place i n the vacuum system that is vacuum sealed.

I 4. Look for some react ion on the vacuum gauge. Th is reaction is

normall y an increase in pressure but i t can sometimes be a

decrease in pressure. (If the fluid washes a piece of dust, or some 0 ring grease, into the hole causing the leak it may seal i t).

I

1. If no leak is found, test each vacuum seal i n the syst em in turn. Oo th is slowly as i t may take the vacuum qauge several seconds to respond.

I

1. If a leak is found, take the vacuum joi n t apart and renew the seal.

I

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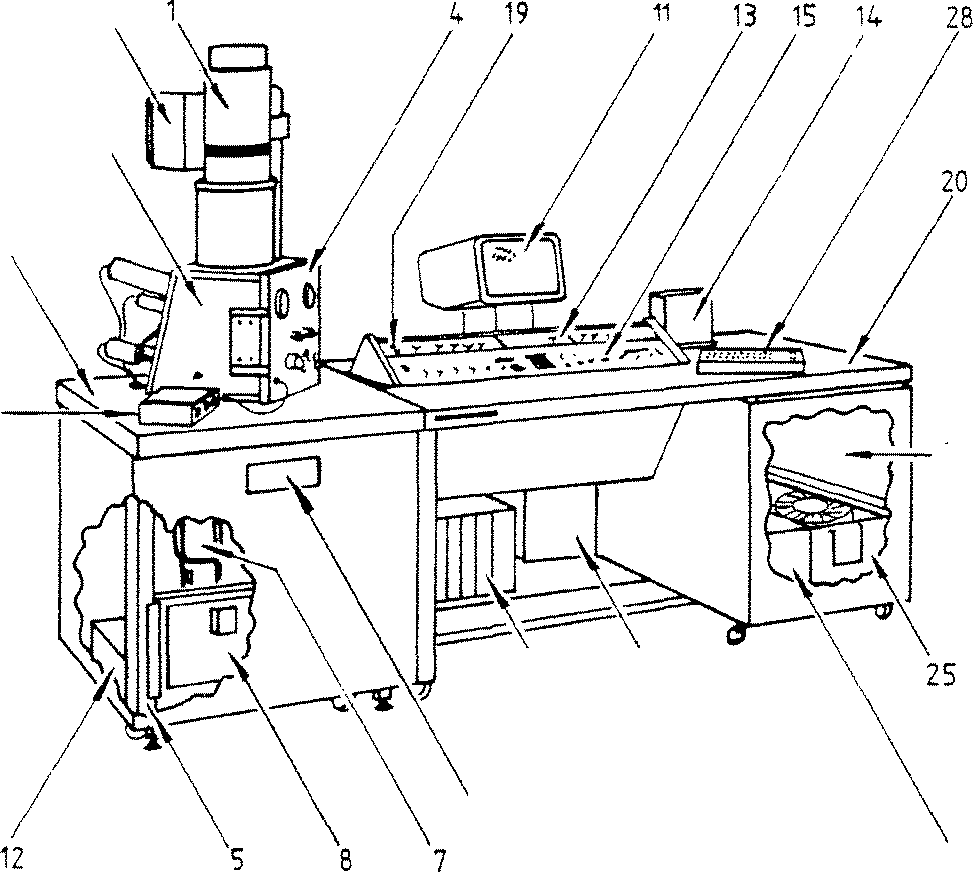
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1 ELECTRON OPTICAL COLUMN 15 CONTROLS PANEL

I

1. ION PUMP (OPTIONAL) 16
2. SPECIMEN CHA MBER 17
3. SPECIMEN STAGE 18

I

1. PLINTH 19 POWER CONTROL
2. PUNT H DESK TOP 20 C ONSOLE DESK TOP

I

1. TUR BO PUMP 21 GUN EHT CRT & PM EHT
2. VACUUM CONTR OL UNIT 22 OPTIONS SPACE

9

VACUUM SYS TEM CONTROLS 23

I

1. SPECIMEN CURRENT AMPLIFIER 24

( OPTION AL I 25 CAPACITOR C HA SSIS

1. VISUAL DISPLAY (POWER C APACITOR DIODES etc)

I

12 TUR BO CONTROLLER 26 ION PUMP CONTROL UNIT

1. OPTIONS PANEL (OPTION AL I
2. RECORD DISPLAY 27 MAINS UNIT

28 TEXT K EYBOARD

**Figure** 3.1

I **Location of Major Items**

I

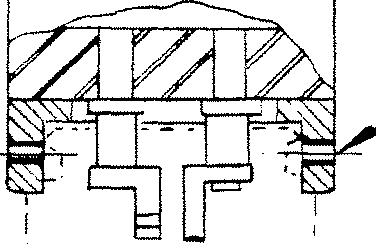
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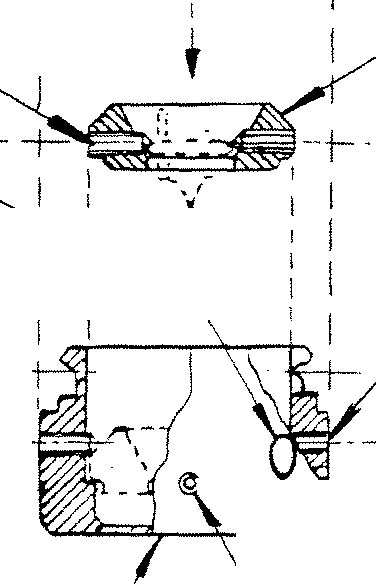
FILAMENT ASSEMBLY CLAMP SCRE W S ( A )

FILAMENT

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I AUGMENT SCREWS( ()!



--CLAMP SURFACE

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CL AMP SCREW S ( B )

I GRI D C A P

HEIGHT SETI!NG

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I Figure 3.3

The Firing Unit

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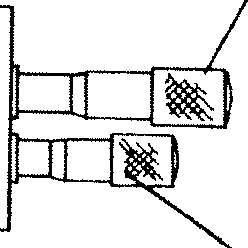
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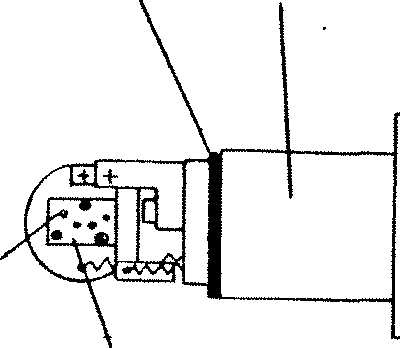
**A pert ures**

( 4 )

Aperture changer

'0' **ring bod y**





Aperture Clamp Plate

**and screws**

Figure 3.4

Final Aperture Changer

B-9993

Aperture changer

Y - shift

**A perture**

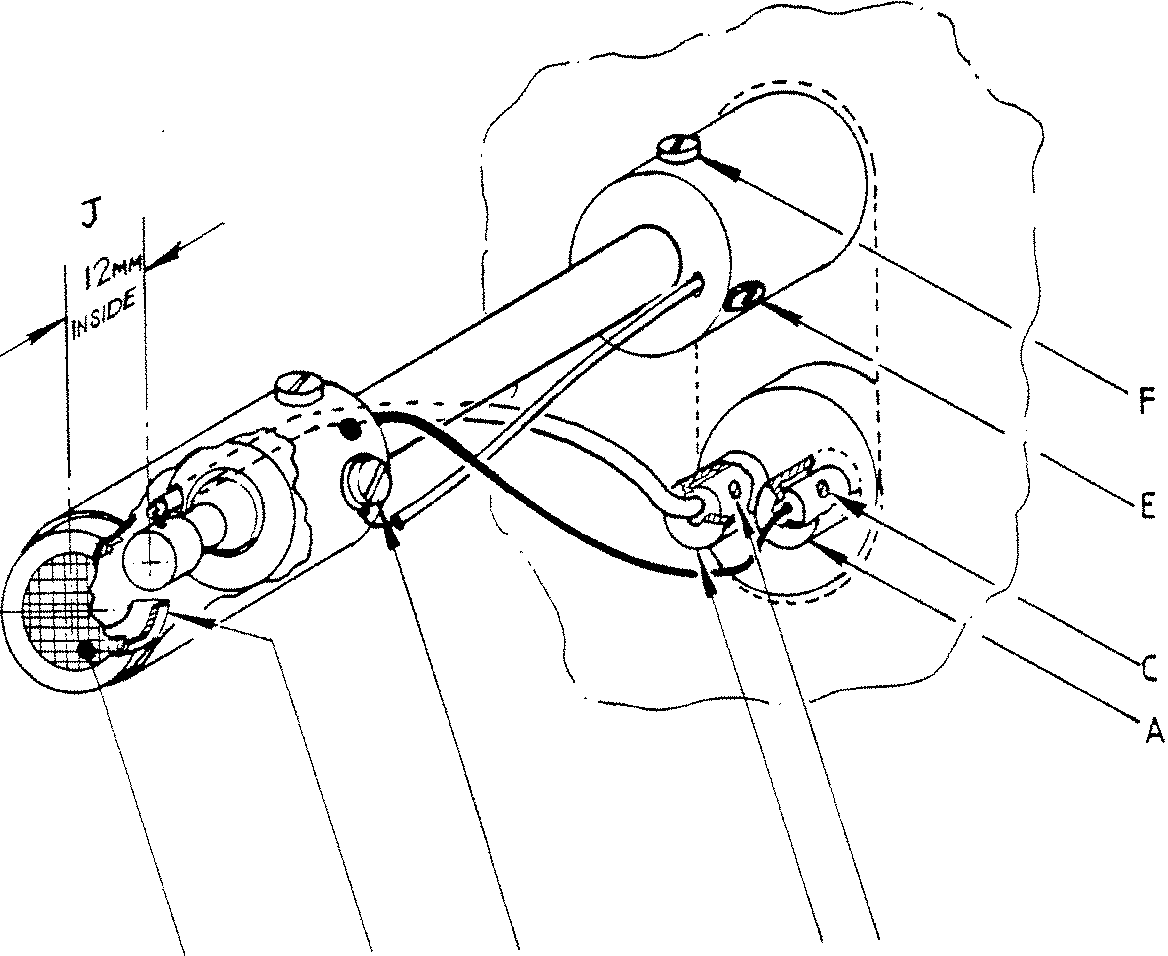
changer

X - shift

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Figure 3.5

Collector System

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(Shield-omi t ted for clarit y - must be replaced)

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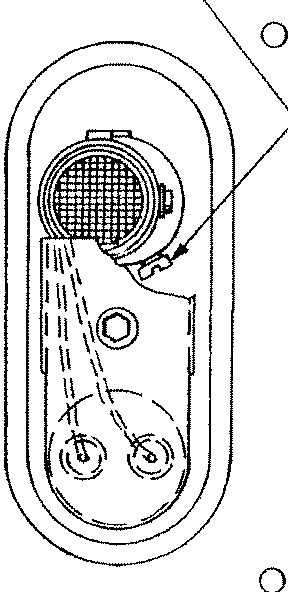
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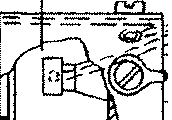
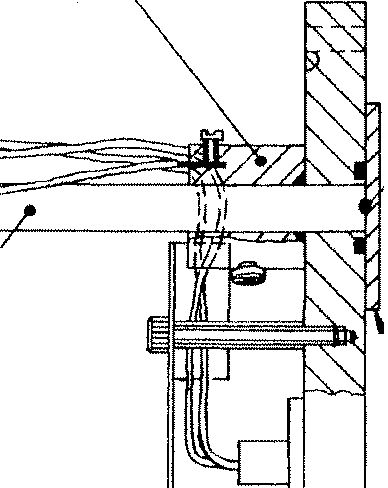
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1v1 o u:·1 t i..g Pl a te and T igfi te1 1 f h ree f.\ t tactimen t S1..:.r EJUJS , inal ly f i,J i-1 t81 1 1 J y lo1 1 L lamp i1 \1\_J Screw .

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Figure 3.5a Collector System

Cam bridge Instru men ts Ud

(Assembly Sequence)

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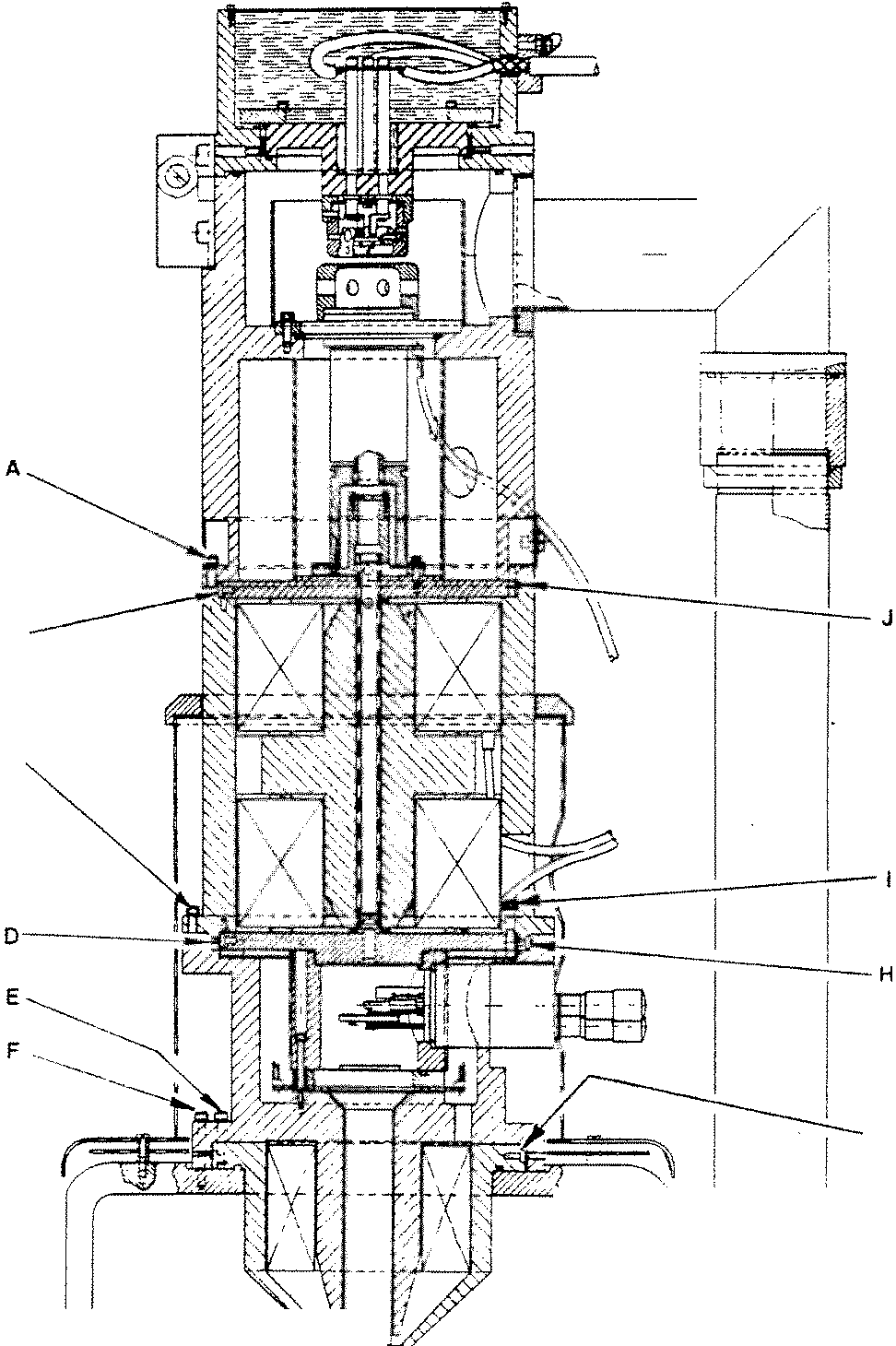
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Figure 3.6

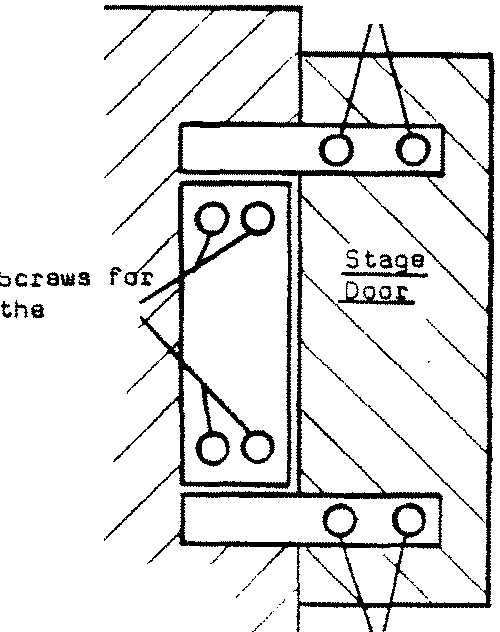
Column Alignment Screws

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**removal** of the door

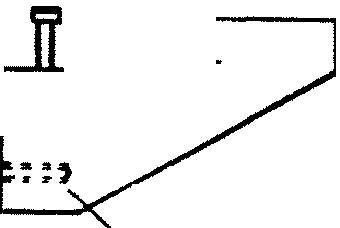
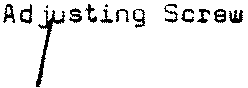
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Hinge

**Lacking screw**

Cham b e£

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Do No t Touch

Figure 3.7

I Stage Hinge Replacement

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I CHAPTER 4 !YTIONS CONTENTS

I

4.1 JNOEPENOENT COLUMN ANO PUMPING (200-ICPI) (\*)

I 4.2 LaB6 (200-l.aB6)

4.3 X-RAY PROCESSOR (200-XPU) (\*)

I 4.4 AUTOFOCUS (200-AFS) (\*)

4.5 BEAM BLANKlNG (200-EBBU) (\*)

I. 4.6 CHAMBER ISOLATION VALVE (200-CIV) (\*)

* 1. SPECIMEN CURRENT MONITOR (200-SCM) (\*)

I

* 1. IMAGE ANALYSIS INTERFACE (200-IAI9) (\*)

I 4.9 CAMERAS (\*)

4.10 FOUR ELEMENT BACKSCATTER DETECTOR (200-4BSD) (\*)

I 4.11 SCINTILLATOR BACKSCATTER DETECTOR (200-SBSD) (\*)

Sections mark ed ( \*) are still being wri t ten.

I

Any sect ions not included in this issue of the manual will be incl uded wit h the

option when i t is supplied.

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I 4.2 LaB6

WHEN HANDLING THE LaB6 EMITTER ASSEMBLY SUITABLE CLEAN FIBRE FREE GLOVES MUST BE WORN. THE LaB6 TIP ON H·E FILAMENT JS VERY FRAGILE. GREAT CARE MUST BE TAKEN NOT TO TOUCH Tl-£ TIP OR DAMAGE IT IN ANY WAY.

I

I 4.2.l Installation Requ iremen ts

The La86 emitter assembly can be fitted to any 5200 provided

that it has the Independent Column Pumping and Isolat ion system fitted (200-ICPI). All con trols used for La86 are fitted to t he basic SZOO and tha EHT set and OPTIBEAM are already configured for LaB6.

I

I 4.2.2 Installat ion

l. Caref ully remove the La86 emitter from its packi ng box. Using an Aerosol duster, clean any dust and loose part icles from the em it ter assembl y.

I

2. Inspect the assembly for any signs of transi t dama ge.

3. Ven t the column and open t he gun.

4. Loosen the three emit ter assem bl y clamp screws and remove the tungsten emitter assem bly. Store it i n the box that the L aB6 emit ter assemb ly came in.

I

I

1. Check the centralizing and height sett ing of the La86 t i p in the firing unit (see Section 4.2.5),
2. Fit the La86 emitter assem bly into the gun and t ighten the emit ter assembly clamp screws.

I

1. Close the gun. Select CHAMBER V acuum and COLUMN

I

Vacuum.

1. On the control uni t f ront panel set the EMITTC:R control to La86. This resets t he EHT set emission current and the OPTIBEAM system for La86 use.

I

USING Tl-£ LaB6 CATHODE WITHOUT HAVING LaB6 SELECTED ON Tl-£ CONTROL UNIT FRONT PANEL WILL SHORTEN THE WORKING LIFE OF THE CATHODE.

I

1. W hen both chamber and column have reached vacuu m ready, indicated by both the cha mber and colu mn vacuu m switches being illu minated, the system may be used.

I

LaB6 EMITTERS SHOULD NEVER BE USED JN A VACUUM WORSE THAN 2\*l!E-6 TORR. IF ICPI IS FITTED AND COLUMN VACUUM IS SELECTED THEN Tf-E SZOO CAf'l\IOT BE USED UNTIL THIS VACUUM IS ACHIEVED, USING La86 WITHOUT!CPI OR WITH A VACUUM WORSE THAN 2\*10E-6 TORR WILL SEVERELY SHORTEN THE La86 EMITTER LIFE AND SHOULD NEVER BE ATTEMPTED.

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* + 1. Ini t ia l Adjustment

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The 5200 is supplied already configu red for LaB6 opera t i on and no adjustmen t should be requ ired.

The emi tter assembly is supplied wi th an emi t ter fitted and adjusted. If any adjustmen t is though t necessa ry the me thod is described in Section 4.2.5.

* + 1. Opera t ion
       1. Install the emi t ter assem bly as described in Section 4.2.2.

1. Select COLUMN Vacuu m and wa i t f or column vacuu m ready to be ach ieved. Th is is shown by the COLUM N Vacuu m sw i tch being illum ina ted.

**Note:** The COLUMN Vacuu m swi tch wi ll be illu m ina ted at the cha m ber vacuu m ready pressure if COLUMN **Vacuum is not selec ted. This indicates a vacuum** wh ich is good enough f or tungsten f i lamen ts bu t is not good enough for La B6 cathodes.

**LaB6 CATHOOES SHOULD NEVER BE USED WITHOUT COLUMN VACWM SELECTED Af'D READY.**

1. Select Co lu mn on the vacuu m meter sw i tch and check tha t the column vacu u m is be t ter tha n 2\* lOE-6 Torr.
2. Select La86 on the EMI TTER switch i n the electron opt ics control grou p.
3. If using a new cathode per form steps 6 to 10. If the cathode has been used go to step 11.
4. Select 0.5kV ACCELER ATION VOLTAGE.
5. Tu rn the filament control fu lly cou n ter clockwise. Select BE AM on. Select EMISSION IM AGE on and centre all fou r GUN ALIGNME NT con trols.

8. Slowly tu rn the F i lamen t con trol clockwise, wa tch ing the

**col umn vacuum rne ter as you do so, tak ing approx i matel y**

lm i nu te to turn con trol f rom fully cou nter clock wise to *l*

clockw ise.

**9. If the column pressure star ts to rise, stop tu rning the** f ilamen t control. Do not inc rease t he filament control u n t il the column vacu u m again reaches 2\*10E-6 Torr.

1. Repea t steps 7 and 8 un t il an emission profile is as sh own in figure 4.2.4C. M ainta in th is cond ition f or abou t 5 m inu tes. Tu rn the f i lamen t con trol to m i ni mu m.
2. Select the req uired ACCELER A TlON VOLT AGE.
3. Select BEAM on. Slowly increase the F i lament con trol un t il an emission image is seen (see F igu re 4.Z.4.A).
4. If the colu mn vacuu m increases du ring step 12, wa i t for i t to recover before proceeding.
5. Increase the F i lamen t control un t i l the emission profile i s as shown in Fi gu re 4.2.4.D. This shou ld be when the filamen t control is at cen tre scale.
6. Use the 5200 i n the normal manner. Af ter a few m inu tes opera t ing, when the laB6 emi tter asse m bl y has reached stable opera t ing cond i t i ons, check the emission prof ile

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I

aga i n. It may be possible to reduce the fila ment con trol

while sti!! ma in taining the correc t prof i le. This wi ll increase the emi tter life.

I

If the LaB6 emi tter is run wi th the filament curren t too low , then y ou will get mu l t i ple images. If the f ila men t curren t is only just too low, the mu l t iple images may not be seen, bu t the resolu t i on wi ll suf fer. If the filamen t cu rren t is too h igh the LaB6 t i p will be too hot and i ts lif e wi ll be shortened.

I

I

The opt imu m filament set t ing will be di f f eren t for d ifferen t cathodes. The actual setting requ ired can only be found using the emission profile ima ge.

I

The filament con t rol should be set at the lowest va lue which gives a solid look ing emission prof i le as F igure 4.2.4.D.

I

1. At the end of an opera ting session tu rn • the filament control to minimu m before switching the beam of f .

I

1. If ven t ing the colu mn wa i t lmin af ter tu rni n g f ilamen t con trol off to allow LaB6 cathode to cool.

4.2.5. Rou tine Main tenance

I If the 5200 image becomes u nstable and sudden i ma ge sh if ts or

dr if t ing focus can be seen then i t may be tha t the emi t ter

assem bly needs cleani ng or the Lab6 cathode needs replacing.

I 4.2.5.1. Replaci ng the Emi t ter (See F igure 4.2.1.).

l. Ad m i t a i r to the column and cha mber. Open

**the gun, remove the emi tter assembly , close**

I

the gun and pu mp down the system.

2. Tak e the em i tter assembly to a clean area for clean ing and reassembl y.

I 3.

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4.

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Place the assem bly on a clea n sheet of paper wi th the grid apertu re downward. Using the flat metal key (1) unscrew the he ight adjusti n g r ing (2). As th is is done the ca thode wi ll mov e away from the gr i d.

Gr i p the cathode pi ns wi th the tweezers prov ided and lif t the cathode assembly out of the gr id cap.

Release the cathode cla mp screws (v isib le i n the four large holes) and, usi ng the tweezers, li f t ou t the cathode.

If the cathode assem bly or gr id aper tu re is not conta minated a new cathode can be f itted. If any cont amina t i on is presen t, disman tle the un i t and clean the componen ts as descr i bed below.

Usi ng the tweezers, pu t the cathode in t o the cathode holder and gent ly t i ghten the cathod e **clamp screws.**

Replace the cathode assem bly i n the gr id cap. Replace the he i gh t adjusting r ing and screw i t down un t il i t touches the sleeve.

Adjust the ca thode hei ght and cen tr ing as

I

I

I 4.2.5.2.

89

Dismantling the Assembl y.

I.

I 2.

Remove the cathode as descr ibed above.

Turn the grid cap *ov er* and press t he centre of the gr id aperture. Th is should separate the aper ture from the grid cap.

I 4.2.5.3.

I

Cleaning the Components.

**DO NOT ATTEMPT ANY CT..EANING OF Tl-£ LAB6 CATHODE.**

All emi tter assembly componen ts can be cleaned using the method below.

I.

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I 2.

I 3.

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I 5.

Remove all signs of cont am ina tion usi ng I micro

Hyprez diamond compound or other ver y f ine grit abrasi ve. The abrasi ve should be carr ied on a sof t f abr ic or a cotton bud. The hole i n the gr id aperture may be cleaned wi th abrasi v e on a cock ta il stick or sof t wooden stick. The faces of the apert ure are best cleaned by rubbing on some abrasive spread on a sheet of CLEA N fine surf aced pa per la id on a FLAT surface (eg, a piece of glass).

Wash all signs of abrasi ve from all componen ts wi th Arklone, propanol or methano l, (or other suit able solvent) pref erably i n an u ltrason ic cleaner.

Wash all componen ts aga in in clean solven t. R epeat step 3.

Dry all components usi n g a hot a i r blower if possible.

4.2.5.4.

I

I I

4.2.5.5.

R eassembl y of the Emi tter Assembl y.

!. Wea r gloves when handli ng any par t of the clean emi t ter assembly.

2. Fi t the grid apert ure into the gr i d cap. Fit the spring which holds the apert ure i n. Check that th e aperture is correct ly seated i n i ts recess i n the gr id cap. If any gap can be seen between the aperture and t he grid then i t is not seated pro perl y (See Figure 4.2.2.).

1. Usi ng the key, screw down the he igh t adjustin g r in g un t il it contacts the sleeve.
2. Adjust the cathode t ip posi t ion as descr i bed in

4.2.5.5.

Adjust ing the Tip Posi t ion

1. Using a low power magn ifier and a good source of illum ina tion, look through the gr id aperture hole and loca te the LaB6 t i p. It ma y be necessar y to adjust the height adjusti ng r ing to *mov e* the cathode forward so that the tip can be seen. Do no t move the tip forward so that i t touches the gri d.
2. As soon as the t ip can be seen through the gr id **aperture hole, adjust the cathode centr ing screws to** centre the t ip in the gr id hole.

I

I 90

1. Adjust the hei ght setting ri ng so tha t the t i p of the cathode is between O.lmm and 0.15mm behind the fron t face of the gr id aperture (see Figure 4.2.3.). When in this posi t ion the t ip is inside the hole in the grid, so care must be tak en to ensure that the t ip is correctly cen tred before adjust ing its heigh t.

I

I

One wa y of seeing when the t ip is at the right hei ght is to look obliquely across the face of the gr id aperture so that the top near side and the bottom far side of the gr id hole are in line (see Figure 4.2.3.). Now adjust the t ip height so tha t the t ip can just be seen. When the t ip is in line wi th the top near side and the far bottom side of the gr id hole, i t is set 0.125mm below the t op face. When doin g this t ake grea t care to ensure that you are see ing the absolute t ip of the cathode, i t is ver y sma l l. This operat ion cannot be done sat isfactor ily without

I

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I using a magni fier to see t he t ip.

4. When the t i p height has been set, check the t ip is still accuratel y cen tred in the grid. Mak e fine

adjustments to the cathode centr i ng screws if requi red.

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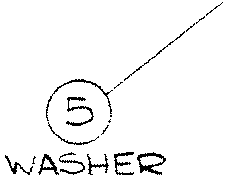
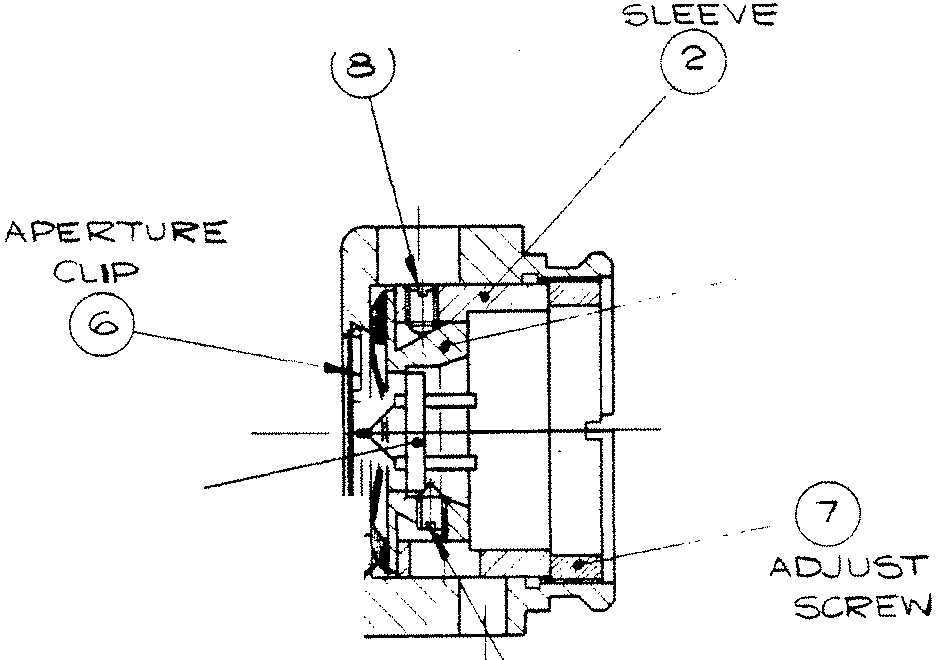
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**REF**

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I Figure 4.2.l

Emitter Assembly

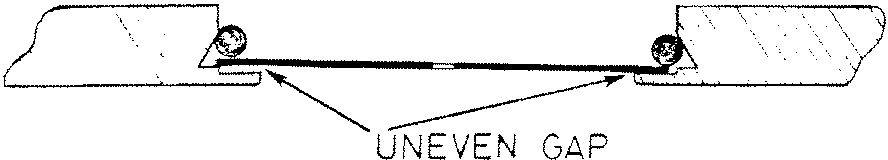
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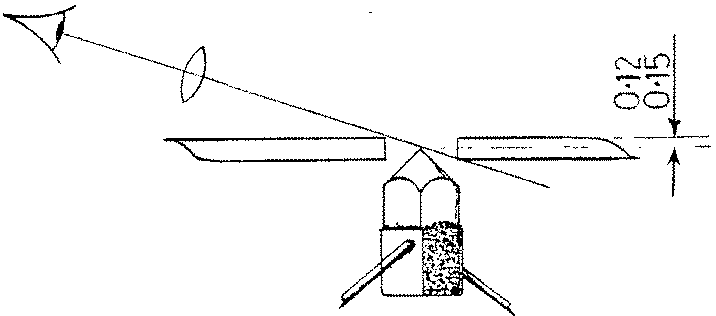
I Figure 4.2.2

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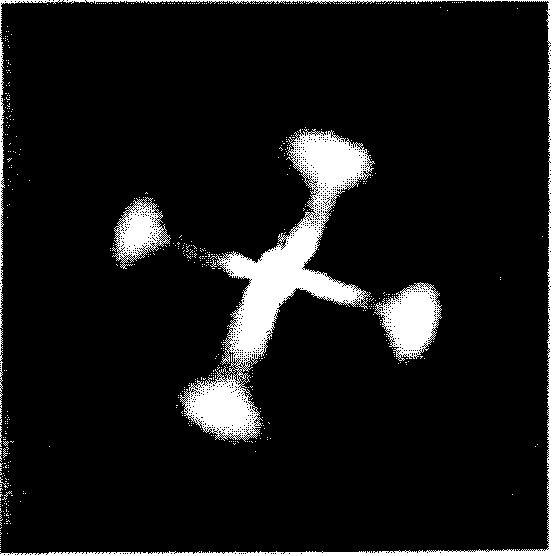
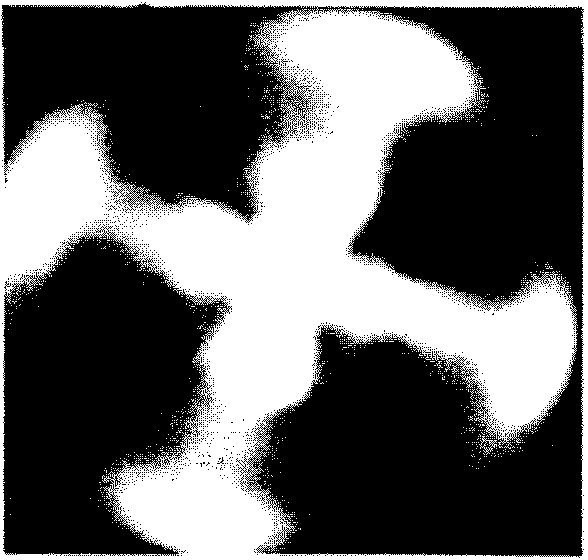


I Figure 4.2.3

Cathode Height Setting

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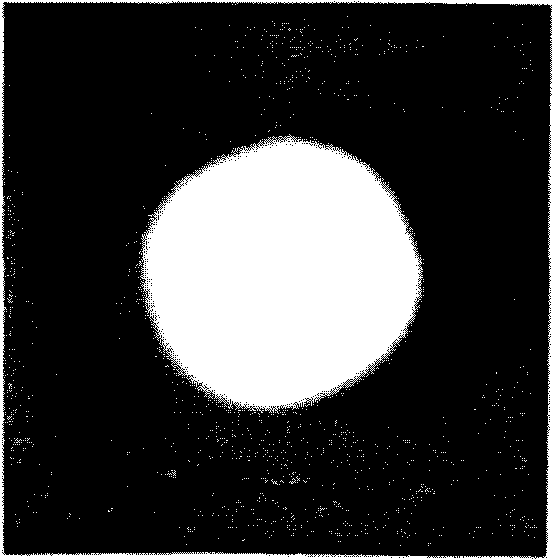
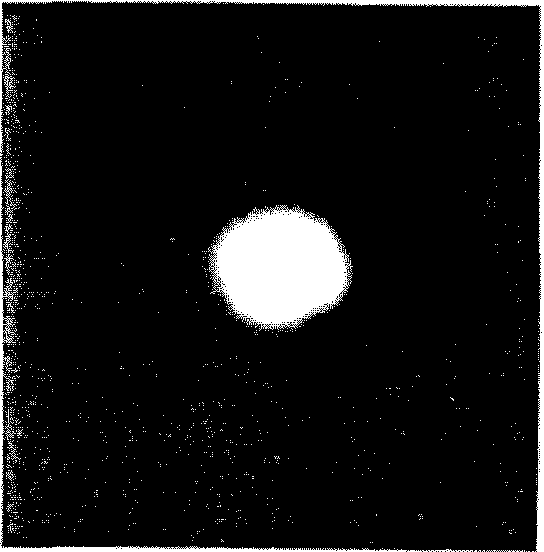
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Figure 4.2.4

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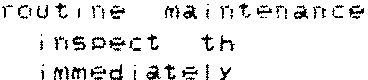
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CHAPTER 5 ADVANCED OPERATING

5.1 INTRODUCTION AND SUMMARY OF IMAGE DEFECTS

I 5.2 NOISE

5.J DEPTH OF FOCUS

I 5.4 SPECIMEN VIBRATION

* 1. FINAL APERTURE CENTRING

I

* 1. SPECIMEN P!-ENOM::NA

I 5.7 RESOLUTION

5.8 PHOTOGRAPHIC CONSIDERATIONS

I 5.9 EXTERNAL INFLUENCES

5.10 SPECIMEN PREPARATION

I 5.11 SUMMARY

5.12 SUGGESTED READING

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I **ILLUSTRATIONS AND TABLES**

Table 5.1

I

Table 5.2

I Table 5.3

Figure 5.1

Fiqure 5.2

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Figure 5.3

Figure 5.4

Figure 5.5

I Figure 5.6

Table 5.4

I Table 5.5

Table 5.6

**l** Table 5.7

Table 5.8

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Table 5.9

I Table 5.10

Table 5.11

**i** Table 5.12

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Image Def ect Types Image Defect Causes

Aberrations and Probe Diameter

Depth of FOCUS Image Offset

Ef f ect of Spot Size on Resolution Depth of Inciden t Electron Penetration Regions of Electron Collect ions

Collection of Backscattered and Secondary Electrons

Factors i n Specimen Preparation •

Electron Source Parameters Electron Optical Parameters **Specimen Parameters** Photographic Para meters General Textbooks Conference Proceedi ngs Specific References Periodicals

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I CHAPTER 5 ADVANCED OPERA TING HOW TO GET THE BEST PERFORMANCE

I

* 1. INTRODUCTION AND SUMMARY OF IMAGE DEFECTS

When you have got this far in the manual you should be qu i te adept a t gett ing an image on the 5200, but a number of ef f ects may still be lim i t ing t he ima ge qualit y. In this chapter these ef f ects are

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**descr i bed in some deta il , as are ways of reducing or eliminat i ng**

I

t hem. Complete elimination of all pro blems is of ten impossible since the art of good Scanning Elect ron Microscopy is one of cont inuous compromise, e.g. you cannot achieve best resol u tion and ma xi mum depth of focus sim ul taneously. The main t ypes of image defects are shown in ta ble 5.1 and the mai n t ypes of cause in table 5.2.

I

In the followi ng chapter the interact ing parameters are d iscussed but, in t he end it is the opera tor who must decide what is required i n the f inal image and who has to put up wi th the compromises.

I

* 1. NOISE

I

Image quality ma y be degraded by a "snowstor m" ef f ect acr oss the whole image, usually ref erred to as noise. The rat io of the wanted

I signal to the unwanted noise depends on several para me ters:

5.2.l ELECTRON PROBE CURRENT.

Th is is determined by the selection of accelera tion voltage, final aperture size, resol ut ion control sett ing. If the probe current is small t he signal to noise ratio is low, the overall

•

* **i rnage contrast is reduced and the amount of noise i ncreases .**

5.2.2 THE ELECTRON EMISSION COEFFICIENT OF THE SAMPLE

I

The more electrons em itted by the sample and collect ed, t he bet ter the signal to noise ra tio. Th is will be discussed i n section 5.7.

I 5.2.3 THE VIDEO AMPLIFIER RISE TIME

The longer the video ampli f ier rise t ime, the bet ter the signal to noise rat io. In the 5200 this is automa ticall y linked to the **scan time. So, for a better signal to no i se, use a slower scan** speed.

**l**

* + 1. THE SCINTILLATOR

**t**

The electron collector scin tilla tor has a limi ted li fet ime and, when i t becomes d iscoloured or damaged, can lead to a

L degraded signal to noise ra tio.

* + 1. PHOTOMULTIPLIER

Excessi ve noise ma y be caused by leak age paths round the photomul t i plier tube caused by dirt or fingerpr ints on the tube.

I

I

I 96

I **5.3 DEPTH OF FOCUS.**

Th is can be considered to be the allowable variation in specimen height, eit her side of the true electron beam focus, within which the specimen appears to remain in sharp focus. It is a function of working distance and fina l aperture size (figure 5.1).

I

To obtain a large depth of focus, use a long worki ng distance or a smaller final aperture.

I

**5.4 SPECIMEN VIBRATION.**

I

Specimen vibration is usua lly only apparent at magni fications greater than about 10,000 times. It is characterised by small image shif ts showing up in the line scan direct ion, usua lly as a repet it ive "sawtooth" ef f ect. [t is caused by spurious movement of the specimen relat ive to the electron beam.

I

True specimen vibrat ion may be due to inadequate fixing of the specimen to its supporti ng stub (see section 5.10) to lack of specimen stage clamping or to a vibration source external to t he 5200 (see

I

section 5.9).

I

Similar image def ects can arise from mild speci men charging (see section 5.5.1) or from specimen hea ting and distortion (see section

I 5.6.2)

5.5 **FINAL APERTURE CENTRING.**

If the final aperture is not correctl y aligned to be concentric wi th the elect ron opt ical axis, focus adjustment will lead to an apparent lateral image shif t, as well as ast igmat ism and a generall y poor image quali ty. The final apert ure should be centred using the **aperture alignment in icrometers and a "wobbling" focus, as descri bed** in section 2.9. The use of FOCUS WOBBLE makes aperture

I

alignment easier.

I **5.6 SPECIMEN Pl-£NOMENA.**

**5.6.l SPECIMEN CHARGING.**

I

Electrons incident upon the sam ple which do not escape as backscattered or secondary electrons are absorbed by the sample. Unless these absorbed electrons can find thei r way to ground (as in a conducti ve sample) they will remai n in the sample resulting in a negati ve charge build up, abnormal

I

image cont rast, i mage shif t and beam insta bili t y.

I Dust and other debris on the sample surf ace can also charge up, and appear as a br ight area on the im age surrounded by a

dark region. The charged debris deflects the inciden t electron beam slight l y, and so t here is reduced electron emission from the area round the debris.

If the sample " i tself is charging, beam deflect ion will occur dur ing scanning, the ef fect being seen as a slow image dr if t followed by a jump back to its original posi tion. Intense sample charging can deflect the beam in to the bottom of the final lens, the elect ron collector system , or any other par t of the specimen chamber or staqe.

97

If a non conduct ive sample is first observed at a high acceleration voltage so that i t charges up and subsequent ly at a lower acceleration vol tage, the lower energy beam will be easily deflected by the charge on t he sample. In this case i t will be necessary to remove the sample from the chamber and discharge it.

I

**l**

**There are several ways to prevent specimen charging:-**

I

1. Coat the sample wi th a conducti ve layer (e.g. C, Au, Au/Pd, Al.) by evaporation or sputter coat ing.

I b. Use a low accelerat ion voltage

1. Use short scan times

I

1. Use backscat tered electron imaging
2. Reduce the collector bias to zero volts.

I

Further deta ils concerning specimen preparation are given in section 5.10.

I **5.6.2 SPECIMEN DAMAGE.**

The loss of beam energy i n the sample occurs mostl y as heat generated at t he point of impact. This can cause physi cal damage (e.g. bend ing) or chem ical damage (e.g. depolymerisation) in the specimen.

I

I The amount o f heat generated depends on:

1. Electron beam power, determined by acceler at ion vol tage

**and specimen current.**

1. Scanned area. If you scan a large area the heat is distr ibu ted.

I

1. The thermal conducti vi t y of the sample.
2. Scanning t ime. The longer the beam is lef t in one place t he hot ter it will get.

I

Biological samples and polymers are especially suscept ible to the heat ing ef f ect. To avoid damagi ng delicate specimens, the following precaut ions should be taken:

I

1. Use a low acceleration voltage.

r

1. Use a low beam intensit y (high RESOLUTION sett ing and small final apert ure) or select EMITTER LaB6 and use a tungsten emitter. This reduces the emission current of the gun f rom 300 microamps t o 80 m icroamps.
2. Red uce the scann ing time, even though this may result in noisy images.
3. Photogra ph large areas at low magnificat ions.

--------- --., ...,....,- --------

I

I 98

1. Ensure that there is adequate specimen coat ing of a conducti ve material.

I

**5.6.3 SPECIMEN CONTAMINATION.**

I

When the electron beam is on the same part of the specimen for a long time any residual organic ma terial in the vacuum environment or on the sample may be decomposed by the electron beam and form a build up of contam inat ion on the sample surface.

I

**Common causes of contaminat ion are:**

I

**a Cleaning solvents. evacuat ion time to** clean ing the column work.

I

You need to allow adequate pu m p out residual vapours af ter before attempt ing high resolution

1. Organ ic or polymeric samples which are unst able i n the

I

**vacuum.**

1. The use of too much vacuum grease on "0" rings.

I d. Unsta ble organic adhesi ve used to f i x sample to stub.

e. Fingerprin ts on i nsi de surfaces of the column and chamber.

I

The ef fects of conta m ina tion are:

I

1. Dark areas lef t on the sample caused by the reduct ion in

**secondary electron emission.**

**i**

1. Decreased resol ution caused by the contami nat ion layer covering the m icrostr ucture.
2. Reduced detectabil it y of low atomic num ber elements during X-ray microanalysis.

I

* 1. **RESOLUTION.**

I

Resolu tion can be def ined as the amoun t by which two adjacen t objects can be seen to be separated.

I

It is found tha t the resolution observable in a scanning elect ron microscope depends on several f actors. These are itemised below, and subsequen tly discussed more f ull y.

* + 1. Electron probe diameter (RESOL UTION Setting)
    2. Accelerat ion voltage
    3. Angular aperture diameter

L

* + 1. Working distance
    2. Aberrat ions (including astigmat ism)

f. Electron gun alignment

1. Final aperture alignment
2. Signal type
3. Specimen t ilt angle and direct ion

j. Photographic frame period

k. Vi brat ion, charging

I 99

I a. Electron probe diameter (RESOL UTION setting)

We ha ve seen earlier that the spot size is a f unction of the

RESOLUTION setting. The greater the RESOLUTION, the greater the demagnifi cation. The smaller the spot size, the better the resol u t ion. The final lens also has an ef f ect on the demagnification. Again the greater the lens current (corresponding to a short work ing dist ance) the greater the demagn ification.

I

I

There is no advant age, however, i n using a small spot size at

I low magnif ications, since image deta il will be lost.

The ef f ect of spot size on the resolut ion is shown i n figure 5.3.

I b. Accelerat ing Volt age

The best resolution is usually obtained at hi gh accelerating voltages because at these voltages the ef fect of chroma t ic aberration is mini mised and the emission f rom the electron gun is br ighter. Diffraction, is also reduced because the electron wavelength is less at higher vol tages. lf the accelerating **vol tage is too highl however, there are certain detriments:**

I

I

1. Lack of surface detail

I

i i. Edge-effects (penetration )

iii. More likelihood of specimen charging iv. Specimen damage

I

**General ly, f i ner surface structures can be seen with lower** accelerati ng vol tages. A t high accelerat ing vol t ages, beam penetration and the dif f usion volume becomes larger, resul ting in unnecessary signals (e.g. reflected electrons) bei ng genera ted wi thin the specimen thus reducing ima ge con trast.

**i**

1. Angular aperture

I

1. Workin g distance

*e.* A berrations (including astigmat ism)

I

These three have an inter acting ef f ect, mai nl y as a result of t he semi-an gular aperture. Electron lenses suff er from lens aberrations (e.g. spherical, chromatic and di f fraction) as well as ast igmat ism. Astigmat ism has been adequatel y discussed and is elimi na ted by the m icroscope stigm ator con trols.

I

I The ef f ect of the aberr ations is to increase the inci dent

electron probe d iameter (d

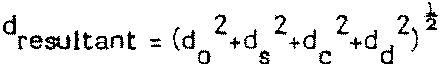
) as shown in Ta ble 5.3.

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where d,, de and dd are the probe diameters due to the eff ects

I of spher ica l, chroma t ic and di ffraction aberrat ions respecti vely.

Also 3

I ct *=* tc °'

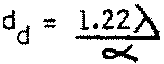
s 5

*=*



dC CC "''(:A"E[

I



**where**

,\ = electron wave length *=* (12.12/JE)$

*=* coeff icient of spher ica l aberra ti on



I

= coe f fic ien t of chromat ic aberra tion

*=* therma l spread of EHT emission energy

E *=* accelera ting vol tage

I A l *=* instabi lity in fina l lens curren t

*=* f ina l lens curren t

I

Cs and Cc are both f u nctions of the work ing distance, and to reduce the i r severe eff ects, the work ing distance shou ld

I

I be short.

Table 5.3 Aberrations and Probe Diameter

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I

I 101

Thus it is found, when all the interacti ng eff ects are considered, that for the best resolut ion, one must ha ve a small angu lar aperture and a short worki ng distance, thus precluding maximum depth of focus. A smaller angular aperture would **give rise to excessi ve noise. A typical working distance is 5rnm.**

I

I

1. Electron gun alignment.

I

1. Final aperture al i gn ment.

If either of these are incorrect reduced resol ut ion will resul t. Poor gun alignment reduces the amount of electron beam hi tt ing the sample, leading to reduced emission and, eventually, noisy images. Misaligned apertures prod uce astigmatism ef f ects.

I

I

1. Signal Type

I When an electron beam interacts wi th a sample, each individual

**electron can undergo an elast ic or inelast ic interact ion**

i n vol ving small or large (respecti vel y ) energy losses.

I

The depth to wh ich an incident electron can penet rate (typically l-5um) a sample before losing all its energy is a f unction of both the incident elect ron energy and the atomic number of the sample. This penetration volume is shown diagrama tica ll y i n figure 5.4.

I

I

Elast i c scatter ing by the atomic nucleus i n vol ves a small momentum (and hence energ y) change of the incident electron wh ich can escape from the sample as a backsca ttered (reflected, primary) electron. Such backsca ttered electrons have a high energy (close to the incident electron beam energy) and are collected from up to several microns depth in the sample. The num ber of backsca t tered el ectrons emit ted is a function of the atomic number of the samples.

I

Inelastic scattering involves a collision between the inciden t electrons and t he orbi tal electrons of the sample atoms. This involves a large energy loss, and the resul tant secondar y electrons ha ve a very low energy (e.g. less than 200 eV) and are easil y absorbed by the sample. They are only collected from the top few hundred Angstroms of the sample surface and thus should be collected for best resolution (see figure 5.4). Too large a penetration volume may ef f ect ively reduce the ul timate resolution.

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1. Specimen tilt angle

Normal SEM images are i n fluenced by the sample surface topography, which cont r ibutes to the collection effi ciency of the electron collect ion system. Backscattered electrons travel in straight lines and are on ly collected if they happen to be travelling towards the electron collector. Secondary electrons can be def lected towards t he collector by havi ng a

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I 102

posi tive bias on its grid. Surface feat ures which are point ing directly towards the electron collector appear bri ght and thus suf f er least f rom noise eff ects under high resol ution

I

cond i t ions (e.g. poi n t B i n figure 5.4)

I An angle in the region of 45° is generally used, but i t is

advisable to adjust the value and observe the eff ect on the

I

**image.**

j. Photographic f rame period

The longer the f rame period, the longer the amplifi er rise time can be wi thout reducing resolution. Long r ise times reduce the eff ects of noise, and thus long f ra me periods should be selected when tak ing high resolution micrographs.

I

I

k. Vibrat ion and charging

Resolution will be severely limited if either of these t wo ef fects are present. Vi br ation of the sample is due to poor sample preparat ion. External vibrat ions are due t o poor i nst alla t ion procedures. Sample charging can be minimised as discussed i n Section 5.4.

I

**5.8 PHOTOGRAPHIC CONSIDERATIONS**

I A good micrograph is sharp and noiseless with opt imum cont rast and brig htness. · These parameters are ver y user dependen t. The camera

and record CR T should be correctl y calibra ted as described in chapter 2. The waveform (as obser ved i n GR A PH) should be evenly distr ibu ted bet ween t he video level markers, nearly spann ing the markers but never going outsi de t he limi ts set by t hem.

I

* 1. **EXTERNAL INFLU::NCES.**

The two most t roublesome external influences are:

I

* + 1. Magnet ic f ields
    2. Mechan ical vi bration

I

They give r ise to image distor t ion and jagged edges. These problems

will not exist if t he room in which the S200 is installed is a room which meets the condit ions laid down in the Stereoscan 200 insta llation recommendations.

* 1. **SPECIMEN PREPARATION.**

Speci mens which are stud ied in the SEM can be di vided into two mai n categories, namely Conductors and Non-Conductors. Factors to consi der during specimen preparat ion are gi ven i n table 5.4.

* + 1. Conductors

These fall in to two groups:

* + - 1. Metallic these are generall y excellent conductors and need no prepar ation.

103

b. Semi conductors-sam ples with a resistance of less than lOE lO ohms can be examined wi thou t special preparat ion.

I

* + 1. **NON-CONDUCTORS.**

This group includes all samples which are not electricall y conducting, e.g. those generally not containing volat iles e.g. fibres, plast ics, polymers, semi-cond uctors wi th a resistance grea ter than about lOe lO ohms.

I

Those generally containing vola tiles e.g. biological and botanical material.

* + - 1. **NON-VOLATILE, NON-CONDUCTORS**

I

For most non-conductors which conta in no volat ile components, e.g. wa ter, tha t would

outgas i n the vacuu m system it is suf ficient to

I

coat the sample wi th a thin layer of conducting medi um such as A u, C, A u/Pd, Al etc.

This layer is t ypicall y 200-300 angstroms in thickness. There are several reasons for t h is coat ing:-

I

* + - * 1. Increased conduct i vi t y of the sample, thus m inim ising sample charge-up, which resul ts in def lect ion of the incident beam and severe degradation of the fina l image. (See Section 5.6.l on Speci men Chargi ng Ef f ects.)

..

I **b.** Increased mechanical stabili ty of the sample due to increased heat conduct ion.

I

1. Increase in pri mary and secondar y electron emission.
2. **Decrease i n beam penetrat ion, result ing**

I

in better spat ial resolution.

The two impor tant current techniques of applying a coating are vacuum evaporation and ion sputtering.

I

Gold is generally used for the followi ng

**reasons:**

l.. 1. High secondar y em ission coef ficient

2. High conduct ion of electrons and heat

1. **Does not oxidise**
2. Good granulari ty of evapora ted or sputtered particles.

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I 5.10.2.2

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Carbon coating by evaporation is generally used if X-Ray m icroanal ysis is to be undertaken on the sample unless, of course, the element under invest igat ion happens to be carbon. Alu m inium could be used in this case.

More recently Pt/Pd and Au/Pd have been used since thei r granulari ty is smaller. Al can also be used, but it has low mechanical strength and can oxidise.

**VOLATILE, NON CONDUCTORS**

Biological and botanical samples, by the i r nature, requ ire relat ively more complex prepara tion procedures. The samples fall into two mai n categori es: a) hard, b) sof t.

a. Hard sample (e.g. bone, teeth, wood). These can be washed to remove extraneous fluids such as blood and mucus, dried in a ir and coated i n the normal way.

b. Sof t Samples

i. Untrea ted

Sof t tissue needs more specialised treatment. Most sof t t issue cont ains up to 90% water which must be removed wi thout altering the structure. If this is not done, there will be d i f f icult y in achieving adequate vacuum in the SEM, and complete or part ial sample collapse and distor tion would occur.

Some botanical specimens can be observed successf ull y for short periods provi ded t ha t thought is given to the selection of instrument parameters, e.g. using a low acceler ating voltage and **beam current.**

**ii.** Replica tion

Although i t is usuall y only adequate for low m agnif icat ion work and for compara t ivel y simple surface topography, replica t ion has t he advantage tha t the sample can be totally preserved. One method of rep! ication **uses an elastomeric materia l such as silicone rubber to obtain an impression.** A posi tive replica is then obtained from the impression by coating i t wi th a low­ viscosit y pol ymethl methacr ylate solution, allowi ng this to dry and then

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stripping the resulant Coating and exam inat ion usual manner.

f ilm away. follow in the

With suitable modificat ion , **electron microscope** techniques can be ut ilised.

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I **iii.** Chemical Pre-treat ment

**transmission**

replication

This technique involves chem ical fixation of the material to strengthen the t issue. There is a large range of chem icals used in this process (e.g. glu taraldehyde and osmium tetroxide) and there are numerous publicat ions discussing the benefits of each. Af ter fixation , i t is necessar y to displace the water i n t he sample by a solvent to aid dryi ng. The met hod must be such that t he specimen su ffers no physical change. The com monest drying agent used is a series of ethanol /water m i x t ures through to 100% ethanol. Havi ng replaced the water present i n the sample there is a choice of three methods for dry ing:

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Freeze Dryi ng

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This is a com pli cated proced ure, and may not be too successf ul. The sample is quench-f rozen and ma i n tained at low

* temperat ures (about -130C) un t il the

sublimat ion process is complete.

Air Dry ing

I

It is worthwhile first transf erring the specimen to a solvent of low volat ilit y (e.g. amyl acetate) as the last stage of dehydr ation. The solvent is then allowed to evaporate from the sample under caref ully controlled temperature cond i t ions. As th is is a gen tle process, there is little chance of any specimen damage.

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Cri t ical Poi nt Drying

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The specimen is dehydr ated as previousl y described and the solvent replaced with

L a liquif ied gas in a small pressure vessel.

The vessel is then heated to above t he critical temperature of the selected gas. Under these condit ions the liquid and vapour phases have the same physical propert ies, so that on venti ng, the liquid **vapourises across cell boundaries and** therefore mi ni mum sample distort ion **occurs.**

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The sample ma y, however, undergo some mechan ical shock during the vent ing stage. The ·choice of gas for this process is li m ited by the num ber of ava ila ble gases which have a cr itical temperature relat ively close to ambient, a safe pressure level and low toxicity , whilst at the same t ime being completel y m iscible in all proportions wi t h the solven t selected i n the f inal stages of dehydration. It is i mportant to replace the solven t com pletely with the liqui f ied gas (usually carbon dioxide) before vent ing.

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I i v. General Considerat ions

The methods described above for sof t

t issue preparation are mai nl y for secondary electron imaging. The problems facing the biologist or botan ist who wishes to und ertake X-ray microanal ysis are dif f eren t in that the **requirements in this case are to maintain**

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the element(s) of interest in t hei r original posit ion i n the sample.

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**There is not one rnajor preparative**

technique for b iological / bot anical

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samples. Where possi ble, several combinations should be tried for a part icular t ype of sample, giving prime consideration to the inform ation sough t. Once a techni que has been est ablished, **instrument parameters and specimen** coat ing methods must be caref ully considered.

I

* + 1. **ATTACHING n-E SPECIMEN TO Tl-E STUB**

The specimen may be attached to t he stub by usi ng any suitable adhesi ve, but care must be taken to ensure that the specimen is not electrica lly insula ted from the stub. Colloidal silver (Silver Dag) or colloidal graphi te (Acquadag) are of ten usef ul for maki ng electrical contact between the edge of the specimen and the stub, and are suppli ed by Acheson Colloids Ltd.

I

For ligh tweight samples (e.g. fabrics, powders, fibres, small pieces of metal etc), the "dags" men tioned above are usually adequate as an adhesi ve. For hea vier and bulkier specimens (e.g. large pieces of met al), it may be necessar y to mi x some glue with the "dag". The glue should be rapid drying, not outgas and be easily soluble in a su itable solvent for subsequen t sample removal and cleani ng (e.g. Durofix).

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I **5.10.4 SPECIMEN EARTHING (GROUNDING)**

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It is possi ble to earth the specimen either direct ly through

t he specimen stage or vi a a specimen current ampli f ier. This facilit y is selected on the stage by a plug situated on the lef t hand side of the stage mechanism looking from the front of t he stage.

If the SCM is no t fitted, or the SCM is fitted but not i n use, i t is essen tial that the specimen is earthed through the specimen stage, otherwise charging phenomena may be observed.

Even wi th coated specimens i t is doubtf ul if the best results will be obtained using an accelerat i ng vol tage greater than 25k V and for the majori t y of invest igations lOkV or 5kV is adequate (whereas best results on conducting samples such as metals are generall y obtained usi ng 25kV ).

It must be emphasised, however, that the operating condi t ions which give the best results on one sample will not necessarily give best resul ts on another sample. All major parameters such as accelera t i n g voltage, spot size are readil y var iable.

**VARY Tf-EM**

* 1. **SUMMARY**

In order to get the best results from a scanni ng electron m icroscope i t is important to consider the following points:

* + 1. Rout ine Operation

R ead caref u lly and understand the operating instructions supplied wi th the instruments and ensure that you are trained by an exper ienced 5200 opera tor (e.g. by participat ing in a Cambr idge Instruments Ltd approved trai ning course. See the fron t of this publication for further details).

**Ensure that the correct routine maintenance has been carried**

out so that the 5200 will genera te the resu lts tha t you require

-e.g. clean or replace the apert ures if the image is astigmat ic.

* + 1. Correct Pa rameter Choice

Read and understand Chapter 5 to appreciate the f undamental considerations. Ref er to published tex tbooks, journal and conference proceed ings concernin g SEMs (some suggested literature sources are given i n Section 5.12). Commun icate with people doing simili ar invest igat ions and find out t heir techniques. (The Cambridge Instruments Ltd Stereoscan users list may hel p to locate relevan t installations.)

Experi men t on your own samples to f ind the best condi tions to use. The 5200 con trols ref lect in choice and locat ion the many years of SEM exper ience incorpora ted in the Stereoscan, and will amply repay considered use.

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I c.

Specimen Prepar ation

108

Incorrect or incomplete sample prepara tion cannot be

compensated for by mal-ad just ment of the SZOO, so caref ul considerat ion of the preparation procedures and adequate **care in their use are pre-requisites to success in the use of** the inst rument.

I

I The important inst rumen t parameters, t heir effect, and thei r

optimum condit ions are summar ised in the following t ables,

toget her with some general com ments. Use the table only as an aide-memoire, and ref er to the rest of Chapter 5 for f urther informat ion.

I

d. Resol ution

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R esolut ion limits in an SEM are thoroughl y consi dered by Goldstein and Yakowitz 1975 (see Sect ion 5.12, 5.8). They discuss a theoretical resol ution limit assuming a 25% contrast level, a secondar y electron collect ion eff iciency of uni ty and certain values of gun brightness, f ield aperture diameter and working distance. They emphasise that the theoretical resolution **cannot** be achieved on all specimens or even with all objects in the same f ield of view of a par ticular specimen. This is especially true of specimens that do no t produce strong second ary topographic con trast.

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Resolution ma y be degraded by boundar y and edge eff ects, both of which are due to the electron collector "seeing" a broader electron probe due to scattering ef fects. The resolution may not be the same i n two diff erent directions i n the same image. For example, if a sample is tilted towards the electron collector, t he electron beam on the sample surface may appear ellipt ical in shape, elongated towards the collector.

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**Remember, opti mum resolution is onl y obtainable fro1n**

I

opt imum specimens.

**5.12 SUGGESTED READING.**

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The tremendous growth of scann ing elect ron microscopy in the years since the advent of the first commercially ava ilable

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instrumen t (the first \* of the long line of "Cambr idge"

Stereoscans) has inevitabl y genera ted a prod igious bibliography of inst rumental, appli cations and techn iques literature. To attempt anything like a complete listing of this in the presen t volume would obviousl y be inappropri ate. lnstead,the Stereoscan user is ref erred to a number of books which provide a general background to scanning electron microsco py, together with a selection of more specialised pu blica tions. Probably the most usef ul items listed in this **section are the various series of national and i ntern ational** conference proceed ings. The serious reader is strongly recommended to become f am iliar with t hese, and will soon ident if y those series whose future even ts are most li kel y to be of special relevance, by vi rtue of con tent, sponsoring body

I or geographical location.

I 109

Whi le Cambr idge Instrumen ts are pleased to be able to provide this introductor y list of publicat ions, and are happy to have been associated directly or indirectly wi th the work descr ibed i n many of these, they regret that they are una ble to provide copies of the publica tions cited. Instead the reader is ref erred to the relevant publishers, especia lly of the conference proceedings, or to sui table national technical

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I librar ies.

For convenience the listed publica t ions are classif ied into a

number of groups under various head ings, bu t it will be appreciated tha t many of the vol umes and art icles cover a wider f ield than the heading under which they are given. New readers will amost certainly find that just one or two ref erences wi ll provide them wi th almost all they rou t inely need. Table 5.8 gives titles of relati vely recen t text books which can be regarded as key integrating publicat ions, some with a usef ul review of the evolutionar y backgrounds to equipment and techniques. Table 5.9 summarises the most import ant cont inuing series of Sl::M conferences, seminars and meet ings, and thei r organisi ng societies. Table 5.10 lists specif ic ref erences under a num ber of sub-t i t les, and Table

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5.11 lists some journals wh ich may occasiona lly i nclude articles of interest.

I

Cou rses on electron microscopy (includ ing scanning electron microsco py) are availa ble at man y uni versi t ies and elsewhere. Details of those held in the UK are usuall y available from the Royal Microscopical Societ y (33/38 St Clemen ts, Oxford, OX4 lAJ, England) or from the Inst itute of Physics (47, Belgrave Square, London SWlX BQX, England) either of whom ma y be able to advise how to locate det a ils of courses elsewhere in the world.

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New 5200 users are strongl y adv ised to part icipa te in an approved operator's tra ining course. Deta ils of courses and enrolmen t procedures are available from accred i ted Cambr idge d istr i bu to rs and service organisa t ions, and from Cambridge Inst ruments Lt d, Sales Oept, Rustat Road,

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I Cam bridge, CBl 3QH, England.

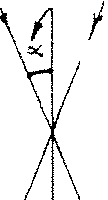
\* eg Stewart A D G and Snelling M. A., "A new scanning

electron m icroscope", Proc 3rd Euro pean Regiona l Electron Microscopy Conf erence, Prague, 1964, pp 55-56.

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Samp le ou t

of focus



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x

1 -r- The Semi-ray angle

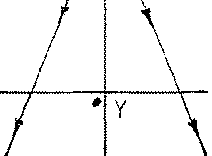
(A ngular A perture)

Depth of Focus

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Sample in

Focus

Electron

Beam

Fo cus

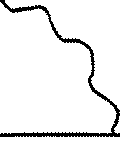
Sample out

I of Focus

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Figure 5.1 Depth of Focus

Direction of Scanning Lines

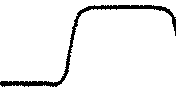
Image Offset. \_.,...



Figure 5.2 Image offset

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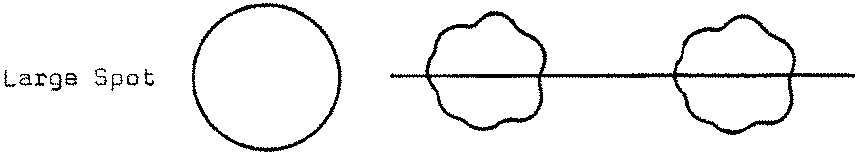
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Good Resolution

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I Bad R esolution

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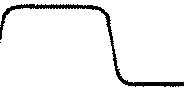


Figure 5.3

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low

low

Eff ect of Spot Size on Resolution

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kV

Z

low kV

high *z*

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I h.1gh kV high kV

I low Z high *z*

Figure 5.4

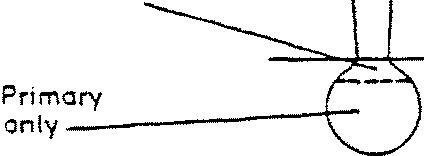
Depth of Electron Penetration

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I Primary and



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Figure S.S

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Regions of electron collection from a sample

A ppearance of:

Collector Bias Region A

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.. +v s backscattered and

R egion 8

secondary electrons

collected

dark

bright

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l nci d•n t

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Primar y

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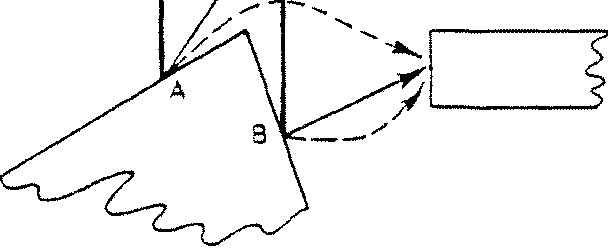
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-ve backscattered

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collected



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black

bright

EJ<ct ron col l<ct or w i t h + v e: or -11 bias

Spq;cimq;n sur taci:

I Figure S.6

Collect ion of backscattered and secondary electrons

- - - - - **lllll!llJ - llllllll!ll** - - Hiii



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1. **Lack of Image Sharpness**

Ast igmat ism not corrected

**Spot Size too large**

Misali gned final aperture

\*Angular aperture too large Work ing distance too long Poor focusing

Unsaturated filament

Filament not aligned, or at incorrect height Too low accelerating voltage

kV inst abilit y due to dirt y gun/anode Sample charge - up or vibra tion

Magnet ic fields (from sample or external) Poor depth of focus

**Too much noise**

Specimen con tami nated or of low potent ial resolu tion

1. **Noisy Image**

Spot size too small for resolut ion requi red Too short f ra me period

Filament not aligned, or at incorrect height Unsaturated filament

Too low accelerating vol tage

Incorrect electron collector bias and volt age Sample not f acing electron collector Inadequate r ise ti me

Faul ty scint illator and/or photomul tiplier Too much CONTR AST, incorrect LEVEL Dark regions of sample be ing observed

**\*Too smaJl an angular aperture size**

**Table 5.1**

**Image Defect Types**

Cambri dge Inst ruments Ltd

(C)

**(D)**

**Poor Final Image Quality**

Insuf ficient resolut ion

Incorrect LEVEL & CONTR AST settings Incorrect accelerating vol tage

Incorrect beam (probe) current

Inadequate specimen preparat ion Incorrect HRR U calibration

**Image Distortion**

Specimen charge-up Speci men magnet ism Speci men vi bration **Speci men damage**

External magnetic fields

FCF in use on highly til ted samples Externa l vi bration

"0ptibeam normally sets the angular aperture correctly.

B-9993

# - -

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(A) Operator error

(C) Sample type and preparation

CAUSE

(1) Under-r un filament

(2) Incorrect probe current

(3) Incorrect gun and final aperture alignment

1. Wrong angular

aperture size and work ing distance

1. Insufficient astigmat ism

**correction**

(6) Wrong scanning per iod

(7) Wrong level selected

(8) Wrong contrast selected

(9) Wrong accelerat ing vol tage

1. External influences

CAUSE

DEFECT

Lack of image sharpness and lack of signal

Low contrast, lack of signal

(if too low), possi ble specimen damage (i f too hi gh)

Lack of image sharpness, image shif t when focusing Lack of resolut ion,

Lack of depth of focus,

**noisey images**

Less image sharpness in one direction, poor resolution Noisy image (too short ), beam deflect ion on charging sample (too long), specimen damage Poor image qualit y

Poor image qualit y

Inf luence on resolution, penet ration and charging

DEFECT

CAUSE

* 1. Atom ic number ef fect

1. Charge-up
2. Overheating
3. Incorrect or inadequate sample coat ing
4. Cont amination
5. Incorrect sample preparation (especi a ll y sof t tissues etc)

(D} Machine Faults

CAUSE

(1) kV instabili ty

1. Gun emission instability
2. Faulty condenser and

DEFECT

Ref lected and secondary elect ron i mages brighten

**with increasing atomic number** Image shif t and distortion, abnorma l contrast

and unst able image Deformation and cracking

of specimen, coa t ing peeling Charge-up or sample damage Surface coat ing leading

to poor i mage qualit y

Sample deformation, damage and charge up

DEFECT

Jagged edged images, focus and br ightness dr i f t

Focus and br i ghtness dr if t Focus and br ightness dr i ft

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | | | objective lens supplies |  |
| (1) | Magnet ic f ields | [mage distort ion, jagged | (4) | Scintilla tor kV discharge | Unsta ble image, noise |
| (2) | Vi br ation | edges in image Jagged edge in image | (5)  (6) | Column contam ination  Scratched fina l lens | Lack of sharpness, bad astigmat ism and i mage dr i f t.  Bad, uncorrecta ble astigmatism |

Table 5.2

Image Defect Causes

Cambridge Instruments Ltd

115

* 1. The size of the specimen must be reduced (if necessar y) to f i t the available speci men holders and speci men stages, but there is of ten an advant age in selecting an even smaller sample size for ease of observat ion.

1. The object must be able to withstand being in the hi gh vacuum of the SEM; i t must not change its shape, and i t must not outgas. A cold stage may help here.

}. It should be clean, i.e. free of dust, oils and greases (Thei r presence can lead to charging and contaminat ion ef f ects).

1. It should be treated to improve the secondar y electron yield i f this is low e.g. coat ing of the sample wi th gold.
2. Any disturbances in the surface structure caused by preparation procedures should gi ve rise to surface deta ils which are too fine to be resol ved at the magnification used to record the images.
3. If an artefact is suspected as a resul t of a preparative procedure, a cont rol speci men should be utilised.
4. The specimen stub should be in good elect rical contact wi th ground potenti al.
5. There should be good electrical contact between the surface of the specimen and the specimen stub, i.e. attach sample to stub wi th conducting pai nt such as Silver-Dag and coat the specimen adequatel y i f necessary.
6. The specimen stub should give rise to as few backscattered and secondar y electrons as possible. Al stubs are normally used, although C stubs are used for some X-ray microanalysis applications.
7. Ver y small particles are best mounted on a low mass foi l to gi ve rise to mini mal in ter fering signals e.g. nylon film stretched over Al ring.

U. The sample must be attached to the specimen holder (stub) so that i t does not move whi lst being irradiated by the elect ron beam.

1. The sample should be attached to the specimen holder (stub) so that all the surface can be studied using the existing stage movements (e.g. t ilt, rotate, X, Y, Z).

**Figure** 5.4

**Factors to consider during specimen preparation**

Cambri dge Instr uments ltd



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|  |  |  |  |
| --- | --- | --- | --- |
| PAR AMETER | EFFl .:CT(S) | | OPTIMUM CONDITIONS COMMENTS  0.4 - 0.6mm Infl uences Resolution and Filament li f e  Correctly Centred Filament ma y drif t early in i ts Iif e  Approx. 2.BA (New fil.) If too high - shortens  fil Iif e. If too low  -reduces resolu tion  High as possible Use less for beam sensit ive samples  Sample dependant Found by expt. Low kV produces low resolut ion contrast, SNR  Must be kept clean Di rt encourages flashovers |
|  | Number of electrons in crossover; SNR  (Signal to Noise R atio)  Source Geometr y; SNR  Con trols Emission; SNR  Number of electrons i n crossover; SNR  Resolu tion; sample damage; penetrat ion; signal emanat ion depth; contrast ; x-ray emission  Stabilit y of Beam |
| Filament - Grid Distance ("He igh t")  Filament Centring Filament Current  Beam Current  Accelera t ing Vol tage  Gr id/ Anode· Cleanli ness |  |

Table 5.5

Electron Source Parameters

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|  |  |  |  |
| --- | --- | --- | --- |
| PA RAMETER | EFFECT(S) | OPTIMUM CONDITIONS | COMMENTS  **If noise is excessive** check gun alignment, collector, sample  May have to trade  D.o. f. vs r esolution  E ff ects most obvious at high magni f icat ion  Effects worse at low kV  **More correction** requ ired at low kV  Ma y have to  **compromise**  LN 2 traps aid pum p down speed |
| Cl/CZ Currents  Final Apert ure  **Diameter**  Final A pert ure Cen t r ing  Spray and Final  Apert ure Cleanli ness Stigmators  Frame Per iod Vacuum System | **Beam diameter,** resolution, SNR, probe current  Beam diameter, aberrat ions, **resolut ion,**  depth of focus, SNR, probe current  **Resolutions, aberrations,** image shif t,  Ast igma tism  Astigmatism r eduction  SNR,  Charging  Filament li fe, EHT stabili ty, contam ination | Small for resolut ion, beam sensitive samples. L arge for XRMA, BSD, CL.  General: - 20um Long W.D: - 50um CL, X RMA: - 50um  D.o.f .:-20um + "50um"  No i mage shif t while focusing  Should be clean  Adjusted to mini mise ast i gma t ic ef f ects  Long - Noise reduct ion Short - Charge reduction  Best vacuum possi ble |

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**Table** 5.6

**Electron Optical Column Parameters**

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|  |  |  |  |
| --- | --- | --- | --- |
| PA RAMETER | EFF EC T | OP TIMU M CONJI TIONS | C Gi'1MEi rs |
| :'-'lour1L1ng un tw  spec 1n1en stuo  Cor1ducti vity and  g r ou11d in9  Sensi tiv ity to  oearn dama,\_;;ie  Coating  Coating    C u a t.i n g  C o a t.i r <;,J  Coating  !''18char:ical S t ab il i t y  E u cen t r ic  Position  Spec1n1en  T il t in g  Sp8cimen  Til ting  5pecirnen  Tilting  Working distance Working distance Working distance  1..Jo r-k n<oJ di s tanc e | C h a r ;Jin g ,  J 1orat1on  Cnar iny Specimen  disto1' t.ion  Conductivi ty  5.E. signal  8 .S .E . sig n al  C .L . sign al  x -r a; si,;i;1al  Specimen curren t  R esolu tion; Cracks in coating  Spec1men t il t in g ,  Stereo pairs Topography , SNR Stereo viewing  X-ray analy sis Resolution  Dep th of focus  Elec tr on collection  B e am aper tu:r e  A n gle ( *ol.* ) | Securely at tached  ::;ood condwction  to ear t h  Use:- Low oeam current,  shor t frame per1oc. Focus away from area o f interest  i\lo C h ar g in g  20nm M etal coating  C arDon co a t;.. ng  Caroon, Alumin1u,n coating Caron , Aluminium coatLng  C - Mater al con trast  A u - Topo9rap11 y Gold  Vibration amplitude  less than required  r esu lu t ian  No translation  motion during tilting  A bou t 45° for E-T  detector. Zero for BSD Tilt difference 5-10°  Depends on detector geometry  Short  L on g  Generally uet ter at lo fHJ WD  Smal l | U se q uick - dr y 1r1 aahesiv e (Preferaol y conductin,;i )  Use cwroduc t1ng  pa.i.n t. (Dag )  O ptimum condi tions may result in poor SNR  Char;)ing seer1 as:  local in tensi ty changes; astig matism; image di s to r tion ; d ar k micro graphs  If t oo thick can  mask deta.tl  I f t o o thick w ill  aosora signal  I f too thick will absoro siy n al  A void .Ln&er f erence with elemen t(s) o f interest.  use inv erted s.c. image for oest topography  Grain size of coating may be resolu tion limit  R educe kV, and  oeam current  U se E u cen t r ic goniometer stage for best results  f" ound by ex p t .  Depends on sample  Use low tilt diff. for large height differences  More critical for  wo s  Beware of final  le n s damage  Limi t = Loss of  resol u t.ion  Poorer resolu tion  at long \rJD  Reduces aoerrations.  Good for D.o.F. |
|  | |

TABLE 5 7 - SPECIMEN PA RAETERS

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| --- | --- | --- | --- |
| PARAMETl::R | EFFECT(S) | OPTIMUM CONDITIONS  Acceptable brightness and contrast for all mags and frame period.  Medi um/Slow 50-400 ASA | COMMENTS |
| Correctly calibrated R ecord system  Film Speed | Information content from micrographs  **"Grain" of image** | More important for Polaroid  Limited by film  available for camer a  **in use** |

I **Table** 5.8

**Photographic Parameters**

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I I I I

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THE USC: OF THC: SCANNING ELECTRON MICROSCOPE

I

J.W.S. Hearle, J.T. Sparrow, P.M. Cross Pergamon Press (1972)

I

THE SCANNING ELECTR ON MICROSCOPC:

C.W. Oatley

Pergamon Press (1972)

I

SCANNING ELECTR ON MICR OSCOPY

O.C. Wells

I McGraw Hill (1974)

PRACTICAL SCANNING ELECTRON MICROSCOPY

J.I. Goldstein, H. Yakowi t z Plenum Press (1975)

I

SCANNING ELECTR ON MICROSCOPY IN BIOLOG Y

I

R.G. K essel, C.Y. Shih Springer Ver lag (1976)

QUANTITIVE SCANNING ELECTRON MICR OSCOPY

I

D.B. Holt, M.D. Muir, P.R. Grant, I.M. Boswarva Academic Press (1974)

INTRODUCTION TO BIOLOGICAL SCANNING C:LECTRON MICROSCOPY

I

M.A. Aayat

Uni versi t y Park Press, Balti more (1978)

I

Topics relevan t to the use of the scanning electron microscope are covered in the ind icated par ts of:

..

"PRACTICAL ME THODS IN ELECTRON MICROSCOPY"

Ed. A udrey M, Glauert, North Holland Publishi ng Co. (1974 onwards)

Vol. 1, Part I Specimen Preparation i n Materials Science

I

P.J. Goodhew

Vol. 2, Principles & Practice of Electron Mi croscope Opera tion

I

A.W. Agar, et.al.

Vol. 3, Part I Fixation, Dehydration and Embedding of Biological Specimens

A.M. Glauert

Vol. 4, Designing the Electron M icroscope L abora tor y

R.H. Alderson

Vol. 5, Part II X-ray Microanal ysis in the electron micr oscope

J.A. Chandler

**Table** 5.9

**General Textbooks**

I

I



I

121

There are a number of conferences held throughout the world for which proceedings are published. The most import ant of these are the proceed ings of the IITRJ conference, edited by 0. Johari and published by IIT Research Instit ute, (!!TRI), Chicago. Known as "Scanning Electron Microscopy, 19.." (1968 onwards) t hey are generally regarded as one of the best sources of papers on S.E.M., usuall y cont a ining extensive bibliogra phies. (Recent volumes have been issued by Scanning Electron M icroscopy Inc., and may be so listed in libr aries), In the Table 3

I

I references these proceed ings are referred to as "IITRI/68" etc.

There were also a series of "Stereoscan" Colloquia held in t he USA from 1968

onwards, for which proceedings were published by Engis Equi pment Co. Inc., or Kent Cambr idge Scientific Inc.

Other international conf erences have been:-

I

Electron Microsco py, 1970 (7th Internat ional Conf erence, Grenoble - French Societ y of Electron Microscopy)

I

Electron Microscopy 1972 (EMCON 72 - 5th European Congress on Electron Microscopy, Manchester, England - Inst itute of Physics)

Electron Microscopy 1974 (Bth International Congress on Electron M icroscopy, Canberra, Austr alia - Australian Academy of Science)

Electron Microscopy 1976 (6th European Congress, Isr ael - Tai Internat ional Publishing).

Electron Microscopy 1978 (9th International Congress on Elect ron Microsco py, Toron to, Canada - Microscopical Society of Canada).

The Electron Microscopy and A nalysis Group (EMAG) of t he Institute of Physics, London, England, also hold conf erences and publish proceedi ngs, e.g:

EMAG 71 Electron Mi croscopy and Anal ysis (Inst. Physics)

EMAG 73 Scanning Electron Microscopy: Systems and Appli cations. (Inst. Physics)

I

EMAG 75 Developments In Electron Microscopy and Analysis,

I Ed. J.A. Vena bles (Academic Press)

EMAG 77 Developments in Electron Microscopy and Anal ysis,

Ed. A.L. Misell, (Inst. Physics)

The Electron Microscopy Societ y of Amer i ca also publish proceedi ngs, e.g.

EMSA 76 34th Annual meet ing of EMSA (Cla i tor"s Publishing Di vision)

Abstract ing journals may also be usef ul, e.g:

L Bullet in Signalet ique Section 761 - Microsco pie Electronique CNRS/EMSA Rue Boyer 26, 75971 Paris.

**Table 5.10**

I

**Conference Proceedings**

I

122

**Table 5.11**

I

**Specific References**

I **5.11.l General Papers on Scanning Electron Microscopy**

1.

I

2.

I

I 3.

I 4.

5.

I 6.

I

7.

I

8.

I

The SEM - Principles and Applica tions

D. Joy

HTRI/73 743-750

Fundamentals of the SEM

R.E.W. Pease llTRI/71 9-16

Introduction to Scanning Electron Microscopy

**W.C. Ni xon,**

IITRI/69 1-10

Fundamentals of SEM for biologists

M.D. Mu ir

l!TRI/74 1011-1018

Fund amentals of SEM for physicists

R.F. Greer

IITRI/ 76 669-674

How to get the best from your SEM

G.E. Pf eff erkorn, A. Boyde, R. Blaschke llTRI/78/l 1-12

The physics of the SEM for biologists

D.C. Joy, C.M. Maruszewski IITRI/78/2 379-390

X-ray anal ysis of biological specimens

J.R. Colem an IITRI/78/2 911-926

**5.11.2 Specimen Coating**

I 1.

I

The ra t ionale and mode conduct ing m aterials.

1. Echlin, P.J.W. Hyde llTRI/72 137-146

of appl ica tion of thin f ilms to non-

* 1. A cool sputtering system for coat ing heat-sensi tive speci mens

I

P.N. Panayi , D.C. Cheshire, P, Echlin l!TRI/77 /1 463-470

* 1. Coat ing techniques for scanning elect ron microsco py and X­ ray microanalysis

P. Echlin

IITRI/78/1 109-132

* 1. S.E.M. O·f mater ia ls wi thout conduct i ve coatings

R.S. Gerdes

Stereoscan Colloqi um/70 9-32

I

123

* 1. Coat ing techniques for S.E.M.

P. Echlin

I

IITRI/74 1019-1028

* 1. Some artefacts associated with sputter coated samples observed at h igh magnificat ion in the S.E.M.

I

V.F. Holland

IIT R!/76 72-74

* 1. Some compar isons of the techniques of sputter evapor ative coating for SEM.

I

P. Ingram et al

I IITRI/76 75-81

5.11.3 **Preparation Techniques {General)**

I

l. A compar ative survey of techni ques for prepari ng

* + surf aces for the scanning electron microscope•

E. Parson, B. Bole, D.J. Hall, W .D.E. Thomas

I J. Micros. 1 01 59-75 (1974)

and

plant

2. The preparat ion of cultured cells and soft t issues for scanning electron microscopy

K.R. Porter, D. Kelley, P.M. Andrews Stereoscan Colloqi um/72 1-20

1. Preparation of animal tissue for surf ace scanning electron

I

**microscopy**

* 1. Boyde, C. Wood

J. Micros. 90 2 21-249 (1969)

I

4. Preparation of sof t biological materials for scanning electron

**microscopy**

D.S. Marszalek, E.B. Small IITRI/69 231-240

**i**

5. Non-coa t ing techniq ues to render biological specimens

I

**conductive**

J.A. M urphy IITRI/78/2 175-193

I

6. **Preparative techniques for the successive examination of**

biological specimens by light m icroscopy, SEM & TEM

V.C. Barber

I IIT RI/72 321-326

1. Preparat ion methods and artef acts in the SEM

G. Pfef f erkorn

I

Stereoscan Colloq ium /69 81-87

1. Preparat ive techniques for the study of sof t biological t issue in the SEM. A compar ison of air dr ying, low temperat ure evaporation and freeze drying.

l.

I.K. Arenberg et. al.

Stereoscan Colloqi um/70 121-157

9. Prepar ation of Biological specimens for S.E.M.

S.A. Luse

Stereoscan Co!loq ium/72 149-153

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124

1. Preparat ion of animal t issue for the S.E.M.

I

* 1. Boyde,

Stereoscan Co!Ioqium/70 189-193

1. Specimen prepara t ion techniques

I

G.E. Pfef ferkorn IITRI/70 89-96

12 A review of problems of interpretat ion of the SEM image with special regard to methods of specimen preparation

I

1. Boyde IITRI/71 1-8

I 13 Techniques for non-conduct ive samples

G.E. Pf fefferkorn

JITRI/73 751-765

I

1. Do's and don'ts in biological specimen preparation for the SEM
   1. Boyde

I IITRI/76 683-690

* + 1. **Preparation Techniques (Chemical)**

I

1. A method of prepar ing bacteri al plaque lining carious cavities for examination by scanning electron m icroscopy.
   1. Boyde, K.S. Lester

I A rchs. oral - Biol. 13 1413-1419 (1968)

2. New methods for detect ing changes i n the surface appearance

of human red blood cells

I

A.J. Salisbury, J.A. Clarke

J. C!in. Pat h 20 603-610 (1967)

3. Some problems of SEM exam inat ion

"•

J.D. Arnold et.al. IITRI/71 249-256

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* + 1. **Preparation Techniqu1 (Drying)**

fi xat ion of selected biological samples for

l. Cr itical point drying techni ques

I

E.R. Lewis, M.K. Nemanic IITRI/73 767-774

1. A rapid method for cell drying for scanni ng electron m icrosco py

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* 1. Liepi ns, E. deHarven IITRI/78/2 37-43

I

1. Critical poi nt drying, cryofracture and seri al sectioning

M.K. Nemanic IITRI/72 297 -304

4. A to tall y automat ic cr i t ical point dri er

J. Powley, S. Dole IITRI/76 287-294

I

I

* + 1. **Preparatioo Techniques (Freezing)**

125

* + - 1. F reeze and F reeze dry in g - a prepa ra tive technique for SEM

I

* + - * 1. Boyde, P. Echl in

I IITRI/ 73 759-766

2. The pre par a t ion , coa t ing and ex am ina tion of frozen biologica l mater ials in the SEM

I

P. Ech lin, R. More ton r!TRI/73 325-332

The prepara tion, exami na t ion and ana\_lysi s of frozen \_ hydra ted **tissue sections by scanning transmisston elec tron microscopy** and X-ray m i croana lysis

3.

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A.J. Saubermann , P. Echl i n

J. Micros. 105 155-191 (1975)

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4. Inst rumen ta tion and speci men prepara t ion for electron beam X-ray m icroanalysis of frozen hydra ted bu lk specimens

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W. Fuchs, B. Lindermann, J.D. Brom bach, W. Tresch

J. M icros. 112 75-87 (1978)

5. Cryofractu ring and low tempera tu re scanning elect ron m icroscopy of plant mater ia l

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P. Ech lin , A. Bu r gess

!ITRI/77/ l 491-500

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6. Prepara t ion of f rozen hyd ra ted t issue sect ions for X-ray microanalysis usi ng a satelli te v acu um coa t ing and transfer system

I

A.J. Sauberm ann , W. R iley , P. Echli n IITR!/ 77/l 34 7-356

.. 7. A copper block method for freezing non-cryopro tec ted tissue

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to produce ice crystal - free regions for elec tron microscopy

Parts f and If

G.P. Dempsey , S. Bulli van t

I

J. Micros. 106 251-260 and 262-271 (1975)

1. The preparat ion of f rozen-hydra ted biological ma ter ia l for X­ ray microanalysis

I

P. Echlin

J. Microscopie Biol. Cell 22 215-226 (1975)

1. A transf er system for low tempera tu re scanning elect ron m icroscopy A. W. Robards, P. Crosby

I

IITR!/78/ 2 927-936

1. F reezi ng, freeze-dry ing and f reeze subst i t u t ion

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A.P. MacK enzie IITRI/ 72 273-280

l 11. **A new freeze-dry technique for preparation of massive**

b iological speci mens for SEM

T. Otaka, S. Honjo llTR!/ 72 359-363

i

I Cambridge Instrumen ts Ltd

I

I

12.

I

13.

I

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Rapid freeze prepara tion of Dict yost il ium discoideum for SEM

R.P. George et.al.

Stereoscan Co!loqi um/70 159-165

Cryofract ure of biological ma teri al

G.H. Haggis l!TRI/70 97-104

* 1. Freezi ng, freeze-fracturing and freeze-dr ying in biological specimen pre parat ion for the SEM.

I

* + 1. Boyde

l!TRl/74 1043-1046

I **5.11.7 Other Techniques**

l. Plastic infil tra t ion as a means of preservi ng t issue for SEM

I

P.H. Cleveland et.al.

Stereoscan Co!loqi uon/70 167-176

2. Use of chem ically react i ve gas plasmas in prepar ing speci mens for SEM and EPMA

I

R.S. Thomas, J.R. Hallahan IIT Rl/74 83-92

I

* + 1. **Replication**

I l.

I 2.

..

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Repli ca techniques for scanning electron m icroscopy • a

**revie•N**

C.H. Pameijer IITRl/78/2 831-836

Review of repli ca techniques for SEM

C. Pfef ferkorn, A. Boyde IITRI/74 75-82

* + 1. **Specimen Charging**

I 1.

Char gi ng eff ects in the SEM

R.O. VanVeld, T.J. Shaffner I!TRI/70 17-24

2. Recent advances in underst anding speci men charging

I

T.J. Shaff ner, J.W.S. Hearle IITRI/76 62-70

I **5.11.10 Stereo Pairs**

l. A quick and easy method for preparing and using stereo pa irs

I

M.T. Parker

Stereoscan Colloqium/70 79-81

l 2.

3.

Interpretat ion of stereo pa i rs

W.C. Love

Stereoscan Col!oqium/70 83-89

Quant itative phot agrammetric analysis and

quali tati ve stereoscopic analysis of SEM image

A. Boyde

J. Micros 98 452-471 (1973)

I

127

I

I Per iodical and journal articles rela ting to scanning electron microsco py are as wide-spread as its var ied applicat ions would suggest. The reader will know best which specia list publication to consult within his own discipline. Genera l art icles, and those relati ng to equipment and accessor y pri nci ples and design, are to be found in pu blications such as t he following:

I

Journal of Ph ysics D: Applied Physics Journal of Physics E: Scient if ic Instruments both published by the Inst itute of Physics

I

I

Journal of Microscopy

published by Blackwell Scient if ic Publicat ions, Oxford, for the Royal Microscopical Soci ety

I Proceedings of the Royal Microscopical Societ y

Scanning - Internat ional Journal of Scanning Electron Microscopy & Related Methods

I

published by Gerhard Wi t zstrock Publishi n g House, Inc. N. Y. & Baden-Baden (from 1978 onwards)

I

**Table 5.12**

I **Periodicals**

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**CHAPTER 6 INSTALLATION**

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**CONTENTS**

I **6.1 INSTALLATION**

Initial installa tion of the Stereoscan 200 should only be attempted by a Cambridge service engineer or an approved Cambridge agent. Any attempt by any other person may invalidate the warranty.

I

The standard S200 is configured for a power supply of between llOV and 250V, single phase. If it is required to run the instrument from two phase power it may be necessary to add an additional fuse into the instrumen t "neutral" line. For details of this see section 6.1.

I

I

These instructions are included mainly for the use of the approved installation engineer, but ma y be of some use to a suitably quali fied user

I who wishes to move his 5200 from one place to another.

When removing any packing material, check that i t has not been used as a

place for hiding some small, vital part of the 5200.

I

Do not throw away **any** packing material unt il the installation has reached a succussf ul conclusion.

I IF IN **OOU3T CONSULT AN APPROVED REPRESENTATIVE OF**

**CAMBRIDGE INSTRUMENTS LTD**

List of Illust rat ions

I Fig 6.1 Floor Plan

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Cambridge Instruments Ltd

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6.1 **INSTALLATION**

Check tha t the room tha t you are going to install the 5200 in meets the conditions set out in the STEREOSCAN 200 INSTALL ATION RECOMMEND AT!ONS.

I Unpack all pack ing crates and carefu lly check their conten ts against the

packing list.

I

Check all packing crates really are empty. Store them somewhere until

* installa tion is complete.

Remove all external wrapping ma terial from the electronics console and the column and pli nth.

I

Posi t ion the electronics console in i ts correc t posit ion, and pu t the plinth on the lef t hand side of the console. (See f igu re 6.1).

I

Open stage and remove transi t clamp and packi ng.

I F i t head amplifier assembly to rear pla te of the chamber. Remember to fi t the insu lating gasket under the assembly and the insulat ing bushes under the screws to ensure that the head amplifier is not in electrical contact

I

wi th the chamber.

R emove the gun transi t clamp. Open the gu n and fit the h igh KV anode onto the top of the lens polepiece assembly. Close the gun (the high K V anode is the shorter one of the two supplied).

I

Remove the foam ru bber pack ing f rom be tween the f an and the tur bomolecu!ar pu mp.

Remove the four plinth suspension system clamp bolts and spacers.

I

**TI-IE TRANSIT BOLTS Af\D SPACERS MUST BE REFITTED F TI-IE**

**INSTRUMENT IS MOVED.**

If the plinth is moved wi thou t the transi t spacers fitted the rubber suspensions may be damaged.

I

I I I I I

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I

Remove any sealing materia l f rom the rotary pu mp, air admi t and turbo pump inlets. Locate the rotary pump and i ts vibra tion isolat ion block either behind the 5200 or on i ts lef t hand side. Connect one of the vacuum hoses f rom the block to the rot ary pump, the other f rom the block to the turbo pump. The "0" rings, carr iers and clamp rings are attached to the isolation block.

Connect the rotary pump outle t to the outside world wi th a suitable exhaust pipe. For details of a suitable pipe see the 5TEREOSCAN 200 lNSTALLA T!ON RECOMMENDATIONS.

Remove protect ive pack ing from all cables in the plinth.

Slide back the two catches (one each end) securing the control un i t i n the console and lower the control uni t to its servicing posi tion. Remove all pack ing ma terial f rom inside the control uni t.

Remove all protective pack ing from the cables in the con trol unit and the lower part of the console. Remove any other packi ng materia l y ou find.

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I lJO

When connecting the cables between the console and the pli n th they must

·· be correctly routed. Those going into the control unit enter the console through the top cable inlet, those going to the EHT set and power supply going through the lower cable inlet. The majori t y of cables are permanently connected at their sources, they only need to be connected to their dest inations.

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[nstall the following cables:

Cable No Source Dest ination

7 '<rotary pump vacuum chassis

1. '-DSA column
2. '.head ampli fier video PCB

|  |  |  |
| --- | --- | --- |
| 49 | 'column | electron optics PCB |
| 56 | **'column** | column scan amp |
| 57 | 'column | column scan amp |
| 58 | "Column | column scan amp |
| 59 | \.column | column scan amp |

1. **"- gun** EHT set filament
2. '-gun EHT set filament
3. **\,,gun** EHT set grid
4. "-.EO PCB column
5. "vac chassis EHT set

67B x *vac* chassis ion pum p control

79 '-head.amplif ier regula tor PCB

82 -.head ampli f ier EHT set

87 '-scan processor column

|  |  |  |
| --- | --- | --- |
| 132 | **xvac chansis** | ion pump control |
| 134 | ...chambe1• | EHT set |
| 142 | 'plinth | **mains uni t** |

Check that all connectors in the control unit are correctly connected.

Check that all other cables in the console and the plinth are correctl y connected.

Fit the pli nth rear panel and connect the air admi t hose from the vent valve to the dessicator. Check that the dessicant is still a deep blue colour. Replace i t if it has turned pink.

Check wi th the customer to see if i t is necessary to install the "neutral" fuse modification (see separate page "THE NEUTRAL FUSE").

Connect the power cable no 1to a suitable source of power. Obta in a working vacuum as described Jn chapter 1rout ine 1.

Remove the turbo pump clamp by removing the 4 screws at the base of the turbo pump and the two M6 screws at the rear of the pli nth.

Adjust the pli nth and console posi tions so that they are posi tioned as in figure 6.1.

I

I

Screw down the plinth feet so that the castors are just above the floor. Screw down the console jacki ng feet so that the console and pli nth tabletops are level (when fitted).

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Check the positions of the console and plinth again.



Fit all panels to the machine. Check that no panels are touching the floating platform and that nothing is shorting out the anti vibration mounts.

I

Raise the control unit to its work ing posi t ion, fit the console desktop and control unit end cheeks. Begin the performance checks.

I

Details of how the controls should f unction are contained in chapter 2.

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**Tl-£ NEUTRAL FUSE**

The standard 5200 is supplied with overcurrent protection in the "live" power connection only. Under certain local conditions it may be necessary to run the instrument from a power source which requires a fuse to be installed in the **0neutral" line.**

I

**INSTALLATION**

I

1. **Cl-ECK THAT Tl-£ 5200 IS NOT** CTED **TO ANY EXTERNAL SOURCE OF POWER.**

2. Remove the lower f ront panel from the console. Slide out the mains unit and remove its cover. (It may be necessary to uncable the mai ns uni t to gain access.)

I

I

J. Locate wire Blue 10 on the back of fuse FS3. Remove it f rom the back of F53 and connect it to one of the tags on the side of FS3. Do not move any other"wires from the back of FS3.

I

**4.** Similarly, move Blue 12 from the back of FS5 to the side of F55.

I 5.

Move Blue 11 from the back of FS7 to the side of FS7.

6. Fit fuses as follows:

Fuse

I

No

Voltage

240V llOV

F53 F55 FS7

lOA 5A

lOA

20A

lOA

15A

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7. Fit the top on the mains uni t, cable i t up and replace i t in the console.

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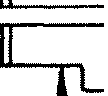
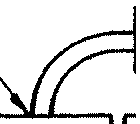
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FLEXIBLE PUMP EXHAUST

POSITION HOSE CENTRALLY IN SLOT

ISOLATION BLOCK

ROTARY T

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PLINTH &

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DISPLA Y &

CONTROL CONSOLE

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CHAIR

Fig. 6.1

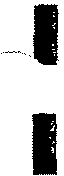
5200 FLOOR PLAN

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###### •

**Cl-IAPTER 7 TI-E SCANNING ELECTRCN MICROSCOPE**



**Contents**

**7.l What an 5EM is.**

I ***1.2* How it Works.**

***1*J What it can do.**

I

**List of Illustrations**

I

Figure 7.l A Basic SEM Figure 7.2 The Electron Gun

Figure 7.3 The Lens

I

Figure 7.4 Stigmators

Figure 7.5 Scanning

Figure 7.6 Electron Collection

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I **7.1 What an SEM is.**

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The basic function of a Scanning Electron Microscope, or SEM, is to prod uce an image of three dimensional appearance deri ved from the action of an electron beam scanning across the surface of a specimen. The size and shape of features on the surface of solid bulk samples can be examined, as can surf aces whose roughness renders their observation very di fficult or impossible by light optical or transmission electron microscopy. The resolution is bet ter than 4nm under suitable conditons, wi th a depth of focus that is at least 300 times greater than that of a light microscope at the limit of resolution. The SEM can have a magnification range from a few times (typically times 10) to several hundred thousand times. The upper magnification is limited only by the resolution available. Samples as large as 7 inches in diameter can be handled routinely, without being damaged by the SEM•

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* **'7.2 How it works**

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The basic operating principle of an SEM is shown in figure 7.l. It can be seen that the SEM consists of five main components.

These are:

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1. **Tl-£ ELECTRON GLN** produces a large, high intensi ty electron beam which is fitted into

I

2. **Tl-£ COLUMN** which controls and shapes the beam into a size useable for scanning microscopy.

**ll**

3. **Tl-£ SCA""8NG SYSTEM** scans the beam over the sample in

a television type raster. The beam scanning over the sample releases electrons from it.

I 4. **Tl-£ ELECTRON COLLECTOR AND DISPLAY** collects

these electrons and converts them to an imgae which can be

viewed by you, the opera tor.

I

5. **Tl-£ CONTROL ELECTRONICS** allows you to control the performance of items 1to 4.

I A more detailed description of how the SEM works will now be given.

It is not necessary to fully understand this at this stage, and many

operators may prefer to leave further study until some operating experience has been gained.

I

**7.2.l The electron gl.l'I (see fig 7.2)**

I

The electron gun, at the top of the electron optical column, produces a beam of electrons with an effective source diameter of about 30 microns. The electrons are emitted from a heated tungsten filament or a piece of Lanthanum hexaboride (LaB6). The emitted electrons are accelerated towards the specimen by the acceleration voltage applied to keep the filament at a high negat ive potential with respect to the earthed anode. The current In the electron beam Is controlled by a bias voltage applied to the grid. This beam is not small enough to produce the def inition required in an SEM.

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The necessary reduction of beam diameter is done in an

·· electron optical system , called the column.

**7.2.Z The column**

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The column consists of three electromagnetic lenses act ing on the electron beam. The action is very similar to that of a li ght source shining into a convex lens producing an image of smaller diameter than the original source (fig 7.3). The successi ve action of the three lenses produces the required diameter of beam to scan the specimen. Unli ke optical lenses the SEM lenses can easily be changed in strength to produce any required beam diameter. This is done by changing the current f lowing in the Jens coil. The first two lenses (mechanically combined into a sihgle uni t in the 5200) produce most of the beam demagnif ication while the third Jens focuses the beam onto the sample surf ace.

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Also in the column is a beam shaper called the stigma tor. The beam, by the t ime i t reaches the sample, may not be exactly circular causing a phenomenon known as astigmat ism. Astigmatism is present when the image is in focus in one axis but is smeared in the direction perpendicular to this. The stigmator can create a magnet ic f ield around the beam to restore i t to i ts original circular cross section, so removing the astigmatism from the image (see fig 7.4).

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For best performance the slenderness of the cone of electron illumi nation reaching the sample needs to be controlled. This "angular aperture" which is very similar in man y ways to the variable aperture in a camera, is obtained by project ing a cone of electron illumination through a defining aperture called the f inal aperture.

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The size of the electron beam on the sample is controlled by the condenser lenses, and the strength (or focal length) of these is determined by the current f lowing through the lens coil. Low lens currents give a weak, long focal length lens gi ving a large, high intensi t y beam. The image produced by such a beam has a very low noise content (i t looks "clean") but is of limited resolut ion. This condi t ion is best for low magnificat ion images, X-Ray analysis and cathodoluminescence.

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As the lens current is increased the beam diameter becomes smaller and the potent ial image resolu tion increases, allowing higher magni ficat ion images to be obtained. But the noise content of the image also increases, maki ng the image more difficult to see. It is like looking through a snow storm. Fortunately slow scan rates as used for photographing images can overcome this problem.

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**7.Z.3 The scanning system**

To produce an image on the display the beam must be scanned *over* the specimen and the display tube in

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I 137

synchronism (figure 7.5). lnformetion coming from any point

·· on the sample cen then be reproduced in the same relative position on the display, building up a point by point reproduction of the sample surface. The magni fication of the

I displayed image is defined as

linear dimension of scan on the display

linear dimension of scan on the sample

I

Since the display is of fixed size, the magnif ication is controlled by varying the scan size on the sample.

I

Various speeds of scan are required, f ast for flicker free viewing, slow for optimum photographic results, and these are provided by the scanning system electronics.

I **7.2.4 Electron collection and video processing. (fig** 7.6)

When the sample is struck by the electron beam many things happen. Some of the incident beam will be reflected as high energy reflected electrons, and some will be absorbed by the specimen, flowing to ground through the specimen current contact. The sample will emit low energy secondar y electrone. .It may also gi ve off X-Rays and light. All of these things can be collected by some form of collector system and used by the SEM to provide you with informat ion about the sample, but the main one considered here is electron emission, collected by the electron collector.

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The electrons leaving the sample are first attracted to a grid biased posi t ively with respect to the specimen. This bias increases the collection eff iciency for secondary electrons. The grid voltage may be held at zero volts to decrease the collection of secondary electrons, resul ting in an image formed mainly of reflected primary electrons. Af ter passing through the grid the electrons are accelerated onto a scint illator, biased at 12KV where they cause light to be emitted. The light is opt ically coupled to a photomultiplier, or PM, whi ch converts the light to electrons and amplif ies them. The signal from the PM is further amplified by the head amplifier and video amplifi er before being used to modulate t he intensi ty of a cathode ray tube display.

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**7***.2.5* **The control electronics**

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This contains all circui ts necessary to control an SEM. What these electronics consist of is not really of any use to the SEM operator, all he or she needs to know is how to use the controls provided to drive the SEM and this will be f ull y explained in chapter 2 of this manual. If you ere really interested in how the control electronics work , f ull details can be found In the 5200 technical manuals.

I

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**7.J What it can do**

The basic function of an SEM ls to produce on a cathode ra y tube en image of three dimensional appearance, der!ved from the action of an

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- I

electron beam scanning the surf ace of a specimen. This technique is fundamentally diff erent from the methods of imaging used in optical or transmission electron microscope.

Many dif ferent types of information can be obtained from the sample.

I

**7J.1 Topogr aphy.**

I

The most common use of the SEM is in the study of the shape and size of the specimen surface, called topography. This is done using secondary electrons, emitted from the sample surf ace with low energy when it is hit by the electron beam. The topography of areas as large as 23mm x lBmm can be presented on a single micrograph. Details as small as 4 Nanometers can be micrographed. (One Nanometer is one millionth of a millimeter.)

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**7J.2 Elemental -1ysls.**

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All samples will emit X-R ays when struck by the electron beam. These X-Rays are characteristic of the element from which they were emitted. By the use of special detectors sensitive to X-Rays the sample may be analysed for its const ituent elements. The resul ts may be either a plot of the concentration of all the elements present, or the spatial distribution of a choosen element on the sample surf ace. Particles as small as 1 Micron may be analysed. (A Micron is one thousandth of a millimetre.)

I

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**7**.3.3 **Cathodoluminescet ice.**

Light is generated in some samples by the electron beam hi tting electroluminescent material within it. A special detector can look at light being emitted from these samples, giving an image of the spatial distribution of such material in the sample.

I

I **7.3.4 Specimen current.**

All specimens absorb some of the electron beam incident on

them. These electrons normally flow out of the sample to

I

ground through the specimen stage earth. If a specimen current amplifier is put in this earth return, images may be

' formed of the specimen current. This can provide val uable information about what is happening below the surface of the sample. In the case of semiconductor samples e.g. integrated circuits, it may be the only method available for getting such information.

I

I

7.3.5 **Transmlaslon.**

If a thin sample is mounted on a suitable specimen stage, with an electron collector mounted below the sample, then an image can be formed of the electrons transmitted through the sample. Although the resolution of an SEM working in the transmission mode is not as good that of a dedicated transmission electron microscope, it can give usef ul pictures of much thicker samples.

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\_ , **7.3.6 Rackscat.tered electrons..**

Some of the electron beam incident on the sample will be reflected back from it, the amount reflected depending on the atomic weight of the part of the sample ref lecting them. These are called backscattered electrons. They can be collected and used to provide images of the variations of atomic number in the sample surface.

I

I Various types of backscatter electron detectors are available

(Annullar, 4 element, scintillator etc) and eny type *may* be

fitted to an 5200.

I

**7.3.7 Ot'-8.**

As scanning electron microscopy develops new detectors and methods of retrieving and processing information are being made available. The above represents the most commonly used. Information on these, and other related topics can be obtained from the publications listed in the bibliography in chapter 5 of this manual.

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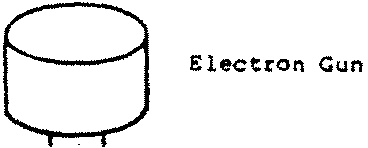
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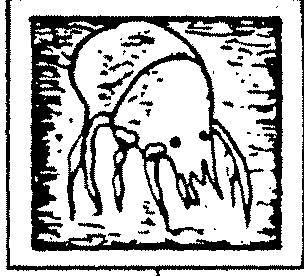
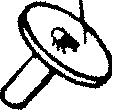


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**Beam**

**Genera tion**

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**Lens**

**Scan**

**Gene.c a tor**

**M&9ni f ieat ion**

**Control**

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**Electron Collector**

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Figure 7.1

Basic SEM

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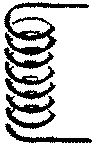
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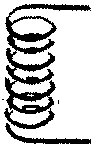
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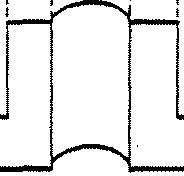
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Figure 7.2

Beam Generation

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Cron Section of Typical Lens

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Figure 7.3

El ectron Source

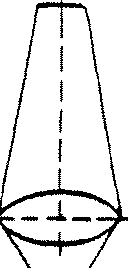
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Image of Source RedJJced i n Diameter

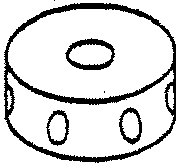
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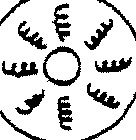
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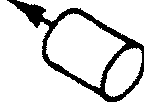
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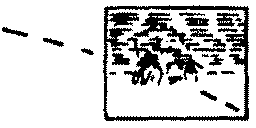
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**Figure** 7.4

**Figure 7.5**

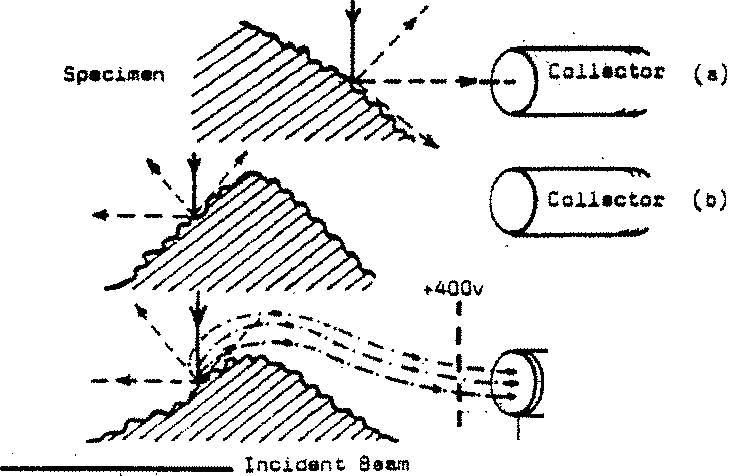
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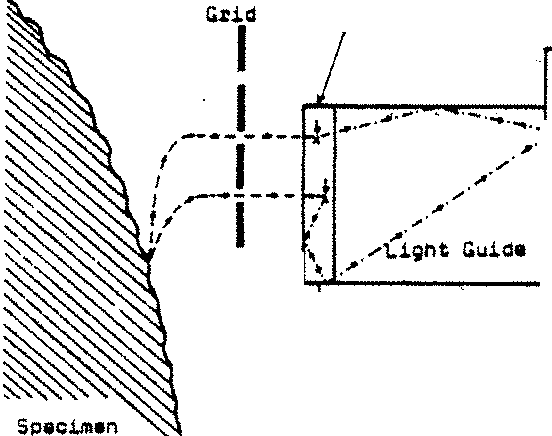
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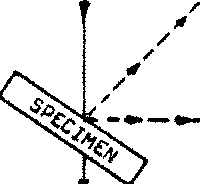
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Electron Collector

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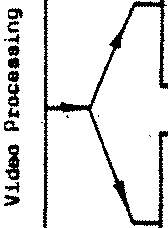
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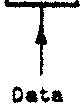
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Display

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Figure 7.6 Typlcill Ute of Basic Video System

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