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USER GUIDE TO PROGRAMS FOR INTERACTIVE IMAGE PROCESSING AND MICRODENSITOMETRY ON THE RGO PDS

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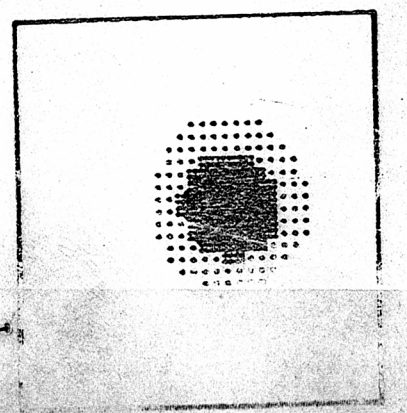
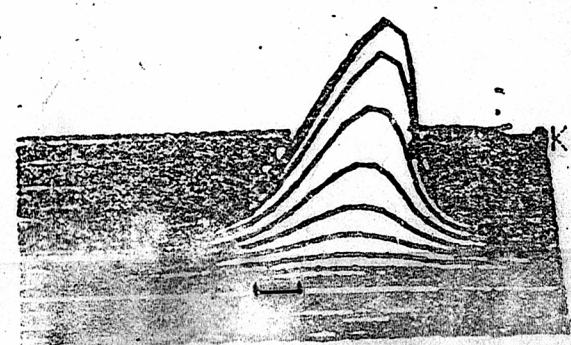
JULY 1979





INTRODUCTION

[ø.1] Conventions:

i) User typed FORTH instructions in capitals.

ii) Terminal response in heavy type.

iii) Comments and descriptions in lower case.

iv) In user typed FORTH instructions, lower case symbols such as: n, m, x, y stand for user typed numbers and are defined in accompanying comments. Numbers are to be assumed to be in 16-bit format (integers, unpunctuated) unless stated otherwise.

v) PDS coordinate directions defined by x and y.

vi) Size of 2-D data arrays on disk or tape defined by ρ (for rows) and κ (for columns).

vii) Pixel identification within those arrays given by j, specifying row number and i, specifying pixel in row (column number).

viii) Some parameters are specified by 2 components. In this case they will be identified using vector notation in the comments. For example $\widetilde{WN}$ is a parameter representing the dimensions of a 2-D array or scan. Its components are 2, 16-bit numbers referenced by WN (κ - direction) WN 1 + (ρ- direction).

[ø.2] Instructions:

FORTH instructions are single words, delimited by spaces. The words will be executed on typing a carriage return (represented here by (cr)). On completion of execution, if execution has not caused any errors, output will be OK . Several instructions may be typed on a line, separated by spaces. They will be executed in turn. FORTH uses a push-down stack for number operations. If an instruction is encountered which is not recognised, the word is echoed back followed by a question mark, and execution is interrupted.

[ø.3] Number entry:

FORTH uses single-precision (16-bit) and double precision (32-bit) signed integers. 16-bit integers are in the range $-32768 \leq n \leq 32767$. These are used for most purposes but sometimes, 32-bit numbers are needed, (for example, PDS co-ordinates). 16-bit integers are entered with no punctuation except a leading minus sign where applicable; ie. the same as FORTRAN integers (but there must be no leading plus sign). 32-bit integers are entered by including punctuation either , . - or / . Any number which includes punctuation (except for a single leading

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minus sign which means a negative number for both 16- and 32-bit numbers) will be treated as a 32-bit number, but it will be treated as an integer, ie. position of the punctuation will be ignored, hence the numbers 12.34 1.234 12,34 are all taken to be the same number, a double-precision 1234. To avoid confusion, it is probably simplest just to terminate with a point (eg. 1234.)

[Ø.4] Basic operations:

Arithmetic is reverse polish; integer only.

Typing a number puts it on the stack.

Typing . prints out the top of the stack.

Typing (number) (address) ! stores (number) in (address).

Constants To put value of constant, R on stack just type

```
R
n ' R !                                  stores n in R
```

Variables Typing the name of a variable, DX puts address of DX on stack. To put value of DX on stack type

```
DX @
n DX !                                   stores n in DX
```

The command ? is equivalent to @ . hence it prints out value in address currently on stack; eg. DX ? prints current value of DX.

To set number base, type DECIMAL, OCTAL or HEX.

For more detailed explanation of subjects in [Ø.2] to [Ø.4], see FORTH course notes, FORTH reference manual.

[Ø.5] FORTH words:

The FORTH compiler only stores the first three letters of each word and its length thus, FILE is treated the same way as FILL; FORTH cannot tell the difference. FILE1, FILE2, FILE3, FILA! are treated the same, but FILEAB is not (different length). This is useful when a long word is spelt incorrectly but can lead to confusion. Also note: CENTRE = CENTER DISK = DISC etc. This applies to 'word', ie. FORTH commands, but not to alphanumeric strings. These strings are

usually used as identifiers or file names. They are only valid if used after a command requiring such a string; such commands include FIND, WRITE, CREATE, ENTER. In this documentation, notation of the form name or filename will refer to one of these strings (eg. FIND filename might be FIND GALAXY. These strings should not have any spaces in them, except where mentioned in the documentation.)

[Ø.6] Interrupt:

"Control C" acts as interrupt. This may not work when tape is being used.

[Ø.7] PDS control:

For user to move PDS stage, the SELECT (blue and white) button must be on 'manual'. For the computer to move it, it must be on 'auto' (eg. when doing a scan). Remember to turn control over when using a command which requires stage movement, as the documentation does not mention this. Control can be turned over before or after the relevant command has been sent.

[Ø.8] Images:

The same basic instruction, PASS, is used to transfer scan data from PDS to tape, or from disk to terminal display, etc, ie. from one representation to another. The format of the instruction is (unit1) SOURCE (unit2) DESTINATION PASS to transfer data from (unit1) to (unit2); the format (location, array size, scan sample interval, etc.) is determined by a set of parameters; each unit has its own set. The whole instruction may not always be typed explicitly, eg. in plotting routines the word PLOT may be defined as SOURCE SCREEN DESTINATION PASS, and so DISK PLOT will transfer the data from the disk to the screen in graphic form.

Each unit name is called an 'image'. A list of 'images' follows.

Images

PLATE	The PDS stage; PLATE SOURCE (unit2) DESTINATION PASS does a scan
DISK	A file on disk. The word DISK is used implicitly in the instruction FIND filename which also selects a specific file.
TAPE	A file on tape
TERMINAL	The terminal; for digital output
SCREEN	The Tektronix terminal; for graphic output

Also:
INPUT
OUTPUT } - Low-level functional images used by PASS
OPERAND

Parameters (these can be treated as 'variables')

LOCATION Disk block number for DISK image; not used for other images.
Value is 5ØØ ⩽n⩽ 2435, lower disc or 5000 ⩽ n ⩽ 9500, upper scratch disc.

~~CN~~ Size of scan in pixels; CN contains number of pixels in a row
CN 1+ contains number of rows in the scan

~~DX~~ Sample interval in microns:
DX contains sample interval in X
DX 1+ contains sample interval in Y

~~CØ~~ Origin of scan in PDS co-ordinates. This is the first pixel in the array, designated pixel Ø, row Ø, (for an nxn array pixels and rows are numbered Ø through n-1.) ~~CØ~~ contains 2 double-precision numbers: CØ contains the X co-ordinate. CØ 2+ contains the Y co-ordinate.

~~WØ~~ A 'window'or subset of the array (on disk, tape, etc.) may be defined. The origin (first pixel of first row) in pixels relative to the origin of complete array is contained in WØ. WØ contains origin in pixels, WØ 1+ contains origin row number. ie. "i", "j" of origin respectively, see [Ø.1]. WØ and WØ 1+ are always positive.

~~WN~~ Size of window in pixels; WN contains number of pixels/row of window.
WN 1+ contains number of rows in window.

KIND Specified direction of scan, ie. scan in x or scan in y.

Current Image

The parameters listed above are not ordinary variables because each of the 8 images mentioned above has its own set of parameters. For example, typing DX will reference the DX of only one of these images, called the "current image". An image is made the current image by typing its name (or using a word which itself used an image name). For instance, TAPE DX ? will print out the current DX value for TAPE, while PLATE DX ? will print out that for PLATE, which may be different. Words which change the current image are:

FIND makes DISK the current image
SET makes TAPE the current image

PASS	makes INPUT the current image
PLOT	makes OUTPUT the current image after setting OUTPUT to be equal to SCREEN
SOURCE	copies parameters from current image to INPUT and leaves the latter as current image
DESTINATION	copies parameters from current image to OUTPUT and leaves the latter as current image
SECOND	copies parameters from current image to OPERAND and leaves the latter as current image

[1] Bootstrap Loading

[1.1]

Follow 'starting up' instructions in black PDS manual up to point where disc is loaded and running: use KTFORTH disc

[1.2] Disk Bootstrap

Press console switches

CTRL HLT/SS (press CTRL and HLT/SS simultaneously)

CTRL BOOT

Response on VDU screen will be a line of numbers, and then @

.....@

Type DK

HELLO ?

..If
: Go to [1.4]
:
:.Otherwise go to [1.3]

[1.3] Bootstrap Failure

Hit "Return" key

OK

..If
: Go to [1.3.1]
:
:.Otherwise try reloading the disk;
see 'closing down' and then 'starting up' again in black PDS manual

[1.3.1] Block Buffers Corrupted

33350 4010 ERASE

Should come back OK

Return to [1.2]

[1.4] Loading

```
JCM LOAD
```

If this fails, e.g. response is JCM? go to [1.3]

```
OCTAL
```

Otherwise output should be

```
*  (SYSTEM MESSAGES)
*
*
   System messages
 0 (USER MESSAGES)
 1
 2 User messages
 .
 .
09/07/79  22:29 OK
```

System date & time

If you do not wish to correct date and time (this is completely optional) go to [1.5]

Otherwise, for example

```
5/Ø9/78 NOW
```

Sets date to be 1978 Sep 5

```
18:Ø7 UT
```

Sets time to be 18:Ø7; GMT and BST are alternatives to UT and are identical, computer does not know about time zones

To print out system date, time

```
TODAY @ .DATE 5/Ø9/78
        .TIME 28:Ø8
```

User messages are inserted by users to inform other users about possible software faults or particular disk files that contain data which other users should be especially careful not to overwrite.

To input a line of text to line n of the user message file, ($1 \leqslant n \leqslant 15$) use the 'Notify Users' command:

```
n  NU/  space text  /  (cr)
```

To input a message to the programmers message file to notify programmers of

a software fault,

NP/ space text/ (cr)

To relist the user message file, type

?U

If required, load magnetic tape as described in black PDS manual. When signing log book, put 'FORTH' in comments column. To close down see PDS manual. In the following documentation, the response OK will be assumed after all commands. Wait for the response OK or ? before typing further commands; if it is ?, the computer has not recognised the command.

[2] Options

Select an option; loading is described under the paragraph number given.
Subsequently loading another option removes the programs for the first option.*

Option name	Brief description	Go to
Bigscan	Scan a plate; store data on tape, or on disk Maximum row size is 12,500 pixels Result may be averaged down by factor of 2^n in x and y, while scanning.	[3]
Taylor	Scan a plate, store data on disk Maximum row size is 512 pixels Align a plate, by creating coordinate transform between it and a reference plate. Graphic output; range of additional sub-options are available, eg averaging down in x and y as in Bigscan, adding, subtracting and dividing two images; contour plots, moving arrays between disk and tape, defect removal, disk file graphic display	[4]
Smoothing	Averaging digitized scan stored on disk, without shrinking array (boxcar convolution)	[5]
3D	3D plot of a scan stored on disk or tape (several versions)	[6]
Photometry	Fitting 2D Gaussians to digitized scan (on disk or tape)	[7]
Additions		[8]
Jplot	Grey scale plotting routine	[9]
	Error conditions	[10]

[3]	BIGSCAN		
[3.1]	Loading BIGSCAN	BIGSCAN LOAD	Wait for the OK before proceeding.
[3.2]	Scanning		
		Set up over desired scan	Scan may be specified by center or any corner.
	To zero PDS coordinates at this point	ZILCH	
	To scan in x, go to [3.2.1]		
	To scan in y Go to [3.2.2]	VERTICAL	
[3.2.1]	If you have most recently scanned in y, then	HORIZONTAL	
	Otherwise, "HORIZONTAL" is default Continue		
[3.2.2]	To set PDS velocity;		
	Either	n MM/S	Sets velocity in mm/s^{-1}
	or	m VEL !	Sets velocity in PDS units (m = 255 n/60)
	To set scan mode;		
	Either	ESCAN	Default. Scans in 1 direction only increasing x, (or y if VERTICAL)
	or	FSCAN	Scans back-and-forth, and flips rows in working storage so final result is same
	Then set up scan parameters as follows:	PLATE	makes PLATE the current image (see [0.8])
		ρ κ WIDE (or ρ κ DIM)	Size of scan; ρ rows with κ pixels in each row.

	δx δy DXDY	Sets parameters $\widetilde{WN}(=\widetilde{CN})$ Sets sampling interval in microns dx is interval in x-coordinate dy is interval in y-coordinate (sets parameters DX)
To check the above parameters	STATUS	Ignore output column marked 'ORIGIN'
If you wish to define the scan by its center Then either	Position over center CENTER	Stores origin (ie coordinates of most -ve Corner) by setting parameters $\widetilde{C\emptyset}$ using current PDS position (x,y) and $\widetilde{WN}$ and $\widetilde{DX}$, such that $x_o = x - \frac{1}{2}w_x \delta x$; $y_o = y - \frac{1}{2}w_y \delta y$ where (w_x, w_y) are (κ,ρ) or (ρ,κ) depending on scan direction.
Or	y. x. $CENTRE	Uses coordinates y. x. (with the decimal point) as scan centre instead of actual PDS position. Otherwise same as CENTRE
Go to [3.3]		
Otherwise define the appropriate corner	Position over corner	
Either	UR	Upper right corner; default
or	UL	Upper left corner
or	LR	Lower right corner
or	LL	Lower left corner These define corner of scan, as seen on PDS viewing screen, not on plate itself. They modify the signs of PLATE parameters $\widetilde{DX}$

..Then either

CORNER

Stores current PDS coordinates in PLATE parameters CØ. This position will be the first pixel (κ = Ø; ρ = Ø) of the scan.

..or

y. x. $CORNER

As CORNER but uses y. x. as origin rather than current PDS coordinates

[3.3] Scanning

For scanning to disk, see the description under TAYLOR LOAD, section [4.7.4]

..If tape is a new tape

REWIND

Rewinds tape, initializes variables

NTP

Writes 1 record and 2 filemarks, then backspaces twice. The record is for compatibility with RT tapes which have no filemark before the first file.

Go to [3.3.1]

..Otherwise the tape may be positioned anywhere before the final double filemark.

[3.3.1] ..If you wish to average down during scan go to [3.4]

..Otherwise

WRITE identifier

'identifier' is a string of ⩽ 40 characters (including spaces). Follow this by carriage return.

(i) Tape will run forward until a double filemark is found, and will then backspace so that the second filemark is overwritten.

(ii) The scan will be performed using the PLATE parameters set previously. The data will be written on to tape in Scansalot format.

(iii) After the scan is completed, a double filemark will be written at the end of the file, and the tape will then be backspaced twice, so that a second WRITE will not require any repositioning of the tape.

```
BIGSCAN LOAD OK
ZILCH OK
3 MM/S OK
ESCAN OK
PLATE 64 64 WIDE 10 10 DXDY OK
CENTER OK
REWIND OK
NTP OK
WRITE TEST SCAN JCM 79AUG4 OK
```

```
VERTICAL OK
5 VEL ! FSCAN OK
PLATE 32 20  WIDE 12 5 DXDY OK
LL 4512. -34128. $CORNER OK
WRITE VERTICAL FSCAN TEST
```

For an example of user commands for a scan using BIGSCAN, see p 15

Go to [3.5]

[3.4]. Averaging to tape

Averages a κ x ρ scan into an array of size INT(κ/a x ρ/a) while scanning

..Either — a AVWRITE identifier

As WRITE (see [3.3.1]) but averages by 'a'. 'a' must be a power of 2. For example, if there are 18 pixels/row, and 'a' = 4, the first 4 rows of 18 pixels each will be averaged down to one row of 4 pixels and then written to tape; similarly for subsequent sets of 4 rows, until the 16th row. Pixels 17, 18 and rows 17, 18 will be ignored.

..or — a AVXWRITE identifier

As AVWRITE but averages in pixel (scan) direction only.

Note: Maximum buffer size is 12,500; the buffer must contain one input and one output row when averaging is being done, ie when 'a' = 4, maximum input row size is 10000 giving an output row size of 2,500

[3.5] Further scans

You may return to section [3.4]; remember to type PLATE so that any parameters modified will be those of PLATE. Reset any parameters by using MM/S, WIDE, DXDY VERTICAL, ODD. You may leave any of these unchanged. Then specify origin using CENTER or UR, (UL, LL, LR) CORNER (or $CENTRE, $CORNER)

[3.6] Reading Files Created by BIGSCAN

Go to and read [4.12]

[4] TAYLOR Options

[4.1] Loading

TAYLOR LOAD

Loads PDS scanning routines, Tektronix graphics routines, least squares fit routines. STARS file routines, and dis file index.
Max. no. of pixels/scan row is 512.

[4.2] Sub-options

There are a number of additional facilities which may be loaded as well as the programs in TAYLOR LOAD. Only one of these options may be loaded at a time, subsequently loading another one will remove the first.

..Either (i)

PROCESSING LOAD

Loads programs to average in i,j and to add, subtract, divide and normalize two disk files

Go to [4.3]

.or (ii) Either

REMOVAL LOAD

or

SLICING OPT LOAD

See [4.9] before loading either
Loads programs to display data from a file line by line, and to remove defect by linear interpolation.

Go to [4.9]

.or (iii)

CONTOUR LOAD

Loads programs for contour plot of disk file.

Go to [4.10]

.or (iv)

SCANSALOT LOAD

Facility to move disk files to tape, and vice versa, read tape files etc. Also scans direct to tape.

Go to [4.12]

[4.3] If you wish to align a plate before a scan, so that corresponding arrays may be obtained from different plates for the purpose of adding two plates of the same object, or for the normalization of electronographs using a photocathode map go to [4.4]

Otherwise, to scan to disk without using the plate alignment facility, go to [4.7]

[4.4] ALIGN

Description of method: 3 or more points (fiducial marks or stars) are entered into a file, called the STARS file, followed by the scan origin coordinates. A scan is done. Corresponding points are then entered in file for a second plate. Least-squares fitting is used to determine angle of rotation needed for the plates to be aligned (the translative component of the coordinate transformation is taken care of by the software but the rotation must be made zero by physically rotating the stage.) After stage is rotated, re-enter points and iterate until angle is acceptably small. (Usually 2 or 3 iterations are enough.) Then the corresponding scan is done.

(NOTE: the stars file is stored on disk so the data will not be lost until they are overwritten by a user.

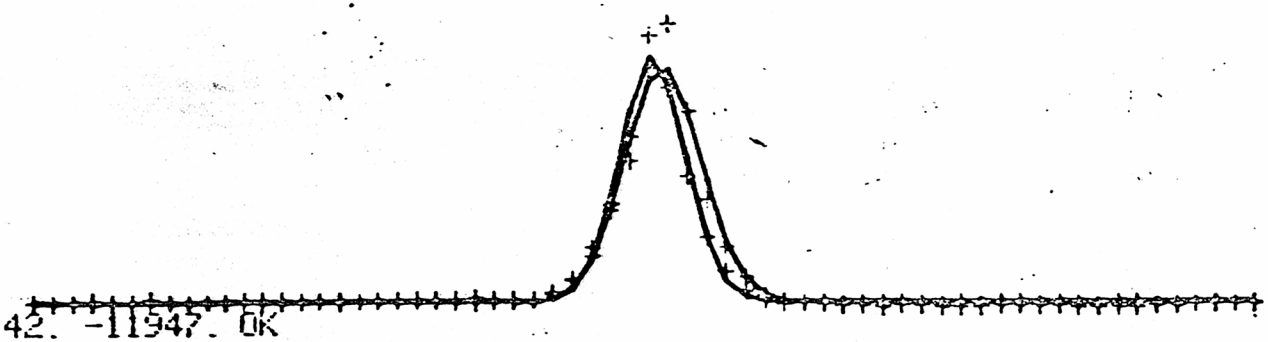
Continue

[4.5] LINK-CLEAR

Clears out stars file.
If there is a set of data already in it (eg. you are aliging different sets of plates) omit this instruction, and place the new data later in the file.

		Position over the first fiducial mark (or star)	If it is a star, you may wish to fit gaussians to it to determine the center point. The word 'mark' will be used (for this section and the next) to mean fiducial mark or star.
	If gaussians to be fitted	1 ENTER name	'name' is ⩽ 6 characters long and is for user identification only, not used in programs. This will do a scan 640 long (64 pixels) in y (center of scan line is the current PDS position,) fit gaussian to the scan line data, plot the data points and the fitted curve on the Tektronix screen; and then do similar scan in x at y value determined by first fit, fit gaussian, type out co'ords of fitted center and enter them and name into record 1 of STARS file. If you are keeping old data in records 1 through n of stars file, you can start at record n + 1 thus n + 1 ENTER name
	Go to [4.5.1]		
	Otherwise	Center over mark 1 $ENTER name	'name' is ⩽ 6 characters long and is not used in programs. Enters name and current PDS coordinates into record 1 of STARS file. If you are keeping other data in the first n records of STARS file, you can start at record n + 1, thus n + 1 $ENTER (name)
[4.5.1]	To check contents of STARS file at any time	STARS ALL	Follow by two carriage returns. Page will automatically be cleared when return key is pressed for a second time
		Proceed to next mark	

```
TAYLOR LOAD OK
PROCESSING LOAD OK
LINK-CLEAR OK
1 ENTER SMALL
```



```
-14142. -11947. OK
```

Example of ENTER

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STARS FILE

#	NAME	X	Y	X	Y	X	Y
1	FLU						
2	FRU	-24778	2	-24767	-11		
3	FRL	-24634	-24628	-24627	-24684		
4	GALAXY	-9478	-11933	-9547	-11916		
5	STAR1	1426	-4209	1356	-4182		
6	STAR2	-22551	-5237	-22626	-5310		
7	STAR3	-21128	-18525	-21180	-18498		
8	HII#1	-10825	-11999	-10991	-11983		

OK

↑ ↑ ↑ ↑ Record These columns not used.

Example of STARS.ALL

If gaussian centering required	2 ENTER name	or n + 2 ENTER name if you started at n + 1
Go to [4.5.2]		
Otherwise	2 $ENTER name	or n + 2 $ENTER name if you started at n + 1

[4.5.2]

Then carry on, using ENTER, or $ENTER to enter consecutive records of the STARS file, until all marks have been entered. Some marks may be entered using ENTER and others using $ENTER.

After all marks have been entered, move the PDS to the position of the scan (or the first scan, if more than one) that you are going to do, and enter the position in the STARS file in the next record, using $ENTER (eg. 4 $ENTER SCAN) Enter all the scans that you wish to re-scan on the second plate in consecutive records of the STARS file using $ENTER. The point that defines a scan can be its center or any of its corners.

To do the scans go to [4.7] for disk or [4.12] for tape and then after scanning go to [4.6]

[4.6] Aligning second plate

You wish to do a scan or scans which will correspond pixel for pixel to a scan done on another plate, whose fiducial or stars have been entered in the STARS file. The new plate must be already roughly aligned by eye with the first one, within a few degrees, (by aligning fiducial marks or stars it should be possible to rotate the plate to within about 5^{o} of the other: this is quite adequate. The program uses the approximation $\sin \theta = \theta$

[4.6.1] Position over first mark ENTERed on first plate

If gaussians to be fitted	1 FIRST	Initializes rotation variables. Scans in y and x as in ENTER, displays results as in ENTER, but stores final

coordinates in second set of x, y columns in STARS file. If for first mark on first plate you used a record other than record 1 (ie. n+1 ENTER name) use the same record here (ie n+1 FIRST).

Go to [4.6.2]

Otherwise

1 $FIRST

Initializes rotation variables. Enter current coordinates in second set of x, y columns in STARS file. The record number used should be the same as for the corresponding mark on the first plate, ie. if (n+1) was used n+1 $FIRST should be used here.

[4.6.2]

NOTE: **The records in the file used for the alignment must be consecutive, but if the first mark cannot be found, find another and use m FIRST where m is the appropriate record number, then type Ø R # ! (or n R # ! if first mark is record n+1) before using NEXT (see below).**

[4.6.3] Then

NEXT

PDS will move to a position corresponding to next record in the STARS file, plus an offset of the coordinate origin calculated from the 2 sets of coordinates in the record for which FIRST or $FIRST was used; ie. where the next mark ought to be if the angle of rotation were zero.

Move the PDS to be correctly over the mark.

In the first iteration the error may be quite large but in later iterations the position reached after NEXT should be close enough to require only a little 'tweaking up'

	If gaussian fit required	OK	Scans, fits, displays, stores in STARS file (second set of columns). Record number was incremented by NEXT.
	Go to [4.6.4]		
	Otherwise	$OK	Stores current coordinates in STARS file (second set of columns). Record number was incremented by NEXT, so will be correct automatically.
[4.6.4]	Then loop back to [4.6.3] until all marks have been stored.		
	Then either	n m ROTATE	STARS file records n through m inclusive are used to fit a transformation between the two sets of coordinates. If first record was record 1 and 3 marks were entered, 1 3 ROTATE
	or	ø i j k .... l NROTATE	Fits records i, j, k, ... l

```
ROTATION
X2     Y2     ANGLE
23.4  -14.2   3.760
12.0   15.0   0.218
137
```

Output from ROTATE
The number immediately under ANGLE represents the angle or rotation in degrees. X2, Y2 are offsets and second, third rows are residuals. The only number the user needs is the angle.

Rotate PDS stage through the appropriate angle

+ve angle ≡ rotate clockwise (platten)
If angle is large, accuracy in rotation is not important due to the approximation in the transformation.

Iterate by returning to [4.6.1]; repeat until angle is sufficiently small.

Then NEXT

This will take the stage to the appropriate scan position (i.e the position corresponding to the scan location entered for the first plate.) The second scan may now be done into a different disk or tape file. (see [4.7] or [4.12]). If several scan positions were stored in STARS file for the first plate, repeating NEXT will move stage to the corresponding positio so all the scans may be done in turn.

[4.6.5] Additional ALIGN commands

y. x. GO

Where y, x are 32-bit PDS coordinates; moves stage to these coordinates. This command is available whenever PDS routines are loaded.

n 1GO

Moves stage to coordinates given by record n of STARS file (1st set of coordinates).

n 2GO

Moves stage to coordinates given by record n of STARS file (2nd set of coordinates).

Graphics mode: The data points for the gaussian fit in ENTER, FIRST, OK are plotted out as crosses. ("POINTS MODE") Alternatives are listed below. Using the word sets the plotting mode until another of the words is used or the graphics are re-loaded.

POINTS

FOLLOW

HISTOGRAM

The commands AXES and BIG GRID will plot axes and a grid on the screen.

[4.7] Scanning

Position PDS over point defining first scan. This point may be the centre or any corner.
If ALIGN has been used this will already have been done.

To zero the PDS coordinates at any time use command ZILCH or by pressing the appropriate buttons on the console displaying the coordinates.

To scan in x go to [4.7.1]

To scan in y type — VERTICAL — Sets y-scan flag

Go to [4.7.2]

[4.7.1] If you have most recently scanned in y then type — HORIZONTAL — Clears y-scan flag

Go to [4.7.2]

Otherwise, scanning in x is default; it is not necessary to type HORIZONTAL unless VERTICAL has been used earlier.

[4.7.2] To set PDS velocity

Either — n MM/S — Sets velocity in mm s^{-1}

or — m VEL ! — Sets velocity in PDS units (m=255n/60)

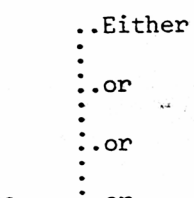
To set scan mode

Either — ESCAN — Default. Scans in 1 direction only (increasing x, or y if VERTICAL)

or — FSCAN — Scans back-and forth, and flips

Then set up scan parameters as follows	PLATE	Makes PLATE the current image (see [Ø.8]).
	ρ κ WIDE (or ρ κ YXSIZE)	Size of scan; ρ rows with κ pixels in each row. Sets parameters $\widetilde{WN}$, and sets $\widetilde{CN}$ equal to $\widetilde{WN}$. Note that first parameter is actually no. of rows and not the Y-direction.
	δx δy DXDY	Sets sampling interval in microns. δx is interval in x-coordinate, δy is interval in y-coordinate (sets parameters DX)
To check the above parameters	STATUS	Ignore output column marked 'ORIGIN'
If you wish to define the scan by its center Then either	Position over center CENTER	Stores origin (ie. coordinates of most -ve corner) by setting parameters CØ, using current PDS position (x, y) and $\widetilde{WN}$ and $\widetilde{DX}$, Such that $x_o = x - \frac{1}{2}w_x\,\delta x$ $y_o = y - \frac{1}{2}w_y\,\delta y$ where (w_x, w_y) are (κ,ρ) or (ρ,κ) depending on scan direction.
or	y. x. $CENTRE	As CENTRE but uses coordinates y. x. instead of current PDS position
Go to [4.7.3]		
Otherwise define the appropriate corner	Position over corner	

rows in working storage so final result is same.



UR	Upper right corner: default
UL	Upper left corner
LR	Lower right corner
LL	Lower left corner

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IMAGES INDEX

#	NAME	LOC'N	ORIGIN:X	Y	DIR.	CORN.	SIZE:X	Y	+X	+Y
1	CART2	485	0.	0.	H	UR	128	128	10	10
		516	640.	640.						
2	CART3	520	-1920.	-1920.	H	UR	64	64	60	60
		527	0.	0.						
3	COPY	470	0.	0.	V	LL	64	64	10	10
		477	-320.	-320.						
4	JCM	400	-2562.	-2560.	H	UR	128	128	40	40
		431	-2.	0.						
5	LONG	600	0.	0.	V	UR	512	4	10	10
		603	20.	2560.						
6	M001	457	-1000.	1000.	H	UL	32	32	10	10
		458	-1160.	1160.						
7	N1065#1	430	-496.	-501.	H	UR	50	50	20	20
		484	14.	-1.						
8	PK	461	0.	0.	H	LR	64	64	10	10
		468	320.	-320.						
9	TEST	459	-1000.	1000.	H	UL	32	32	10	10
		460	-1160.	1160.						
10	TWIN	432	0.	0.	V	UR	64	64	10	10
		439	320.	320.						

OK

(Name) Starting block / Finishing block — x origin / x center — y origin / y center — Horizontal or Vertical scan? — Which corner? (CENTER=UR) — X pixels (K) — Y pixels (P) — δx microns — δy microns

Example of LISTFILE

	..Then either	CORNER
	:	
	:	
	:	
	:	
	:	
	:	
	:.or	y. x. $CORNER.
[4.7.3]	: If you are scanning to tape using SCANSALOT LOAD, go to [4.12]	
	:	
	:.Otherwise go to [4.7.4]	
[4.7.4]	Scanning to disk	
		SOURCE
		LISTFILE (cr) (cr)
	To store image starting in a block higher than this (usually the next block) allocate the file by	n CREATE filename

These define corner of scan, as seen on PDS viewing screen, not on plate itself. They modify the signs of PLATE parameters DX.

Stores current PDS coordinates in PLATE parameters C$\tilde{\emptyset}$. This position will be the first pixel (i = $\emptyset$, j = $\emptyset$) of the scan.

Analogous to $CENTRE

Specifies PLATE (the current image) as the source for the pass (scan operation). The parameters set up in PLATE will be copies to INPUT. SOURCE leaves INPUT as the current image (ie use of WIDE etc. will modify INPUT parameters, not those of PLATE.

LISTFILE must be followed by two carriage returns, it automatically clears the page (on the Tektronix) It prints out index of data for current disk files (see example attached). If the index takes more then 1 page, press any key except PAGE to clear page.

1 Block takes 512 pixels (32 x 32 array ≡ 2 Blocks.)

To remove old files in the index that are no longer used	REMOVE filename	n is starting block number (500 ⩽ n ⩽ 2435). Block nos. 5000 to 9500 access the upper (scratch) disc. filename is a string of ⩽ 8 characters. This creates a file accessed by the command FIND filename (Do not begin filename with an S!)
		Remove entry from index; Files Should be removed as soon as they are finished with. This command can be used at any time.
	n m LISTB	Restricted LISTFILE that only lists files occupying disk space between blocks n and m. (n < m)
	n UP LISTB	Lists files occupying space from block n upwards.
If you have done a PROCESSING LOAD (or do one at this point) and wish to use the averaging capability for this scan, go to [4.7.5]		
Otherwise	FIND filename EQUAL DESTINATION	FIND filename selects the file (the one just created, usually) EQUAL copies INPUT's parameters to DISK and DESTINATION specifies DISK as the OUTPUT image, copying parameters from DISK to OUTPUT.
	PASS	Passes INPUT to OUTPUT. Since INPUT is PLATE and OUTPUT is DISK, PASS will do a scan according to the parameters set up, and store the data on disk. Remember to select AUTO on PDS.
If you are using ALIGN and now wish to align second plate, go to [4.6]		
Otherwise, continue		

..If you wish to do further scans,
: go to [4.7]
:
:..Otherwise, return to [2] or
finish.

For further capabilities in PROCESSING LOAD see [4.8]

[4.7.5] Averaging

a AVDISK filename

Selects disk file
Stores a (number to be averaged by; $a = 2^n$) in AV
Takes INPUT parameters, multiplies or divides by AV where appropriate, and puts them in DISK'S parameters.
Specified DISK as the OUTPUT (copies DISK'S parameters to OUTPUT)
Modified PASS - average in i and j, scans a line, puts this in working storage. Takes first AV numbers, adds each into first location of "sum buffe next AV numbers into second location, etc. Before being added in, numbers are divided by AV^2; 2nd, 3rd... AVth scan line added in and then sum buffer stored as 1st row of output array; sum buffer zeroed. Repeated for every group of AV scan lines, so final array will have each number being the averge of AV^2 numbers; eg. a scan 64 64 WIDE with 4 in AV will result in an output array of size 16 by 16 with sample size multiplied by 4 in each direction. ie. 1Ø 1Ø DXDY will have an output dx, dy of 4Ø, 4Ø).

a AVXDISK filename

As AVDISK, but averages in i (ie scan direction) only and not in j (ie row direction)

..If you are using ALIGN and now
: wish to align second plate, go
: to [4.6]
:
:.Otherwise, continue

..If you wish to do further scans, go
: to [4.7]
:
:.Otherwise return to [2] or finish

For further capabilities in PROCESSING LOAD see [4.8]

[4.8] Further capabilities in PROCESSING LOAD

[4.8.1] Combining disk images

For two disk files (file 1) and (file 2) to be arithmetically combined to form a third file (file 3) use the following instructions.

FIND file 1 SOURCE	file 1 is identified with INPUT
FIND file 3 DESTINATION	file 3 is identified with OUTPUT
FIND file 2 ADD (SUBTRACT) (DIVIDE)	file 2 is identified with OPERAND by using one of the words.
PASS	PASS combines data in INPUT with data in OPERAND and places the result in file 3

The commands defining the OPERAND are:

ADD	giving (file 3) = (file 1) + (file 2)
SUBTRACT	giving (file 3) = (file 1) - (file 2)
DIVIDE	giving (file 3) = NUM x (file 1) / (file 3)

where NUM is a variable (default 1000) which may be set by n NUM !

Each element in the INPUT array is combined with the corresponding element in OPERAND array row by row in working storage. The INPUT and OPERAND files are unaltered.

..If you wish to overwrite file 1 with the result then

```
FIND  file 1  SOURCE DESTINATION

FIND  file 2  ADD (SUBTRACT, DIVIDE)
PASS
```

..Otherwise, finish. However, if you wish to overwrite (file 2) with the result, then

```
FIND  file 1  SOURCE
FIND  file 2  DESTINATION
ADD (SUBTRACT, DIVIDE) PASS
```

[4.8.2] Sum and average of an array

SBAR will calculate the average value of an array and both print it out and store it in the variable NUM. The sum of the array is stored in the double precision (32-bit) variable XSUM, to see value; XSUM 2@ D.
To subtract a constant background value n throughout the calculation (while not altering the array itself)use the command

```
n BKG !
```

before using SBAR; default BKG is zero, after changing it, it will stay at current value until altered again or until PROCESSING is reloaded.

```
FIND  filename  SBAR  AVERAGE VALUE
= 1025                              calculates sum and average
```

[4.8.2.1] Subtraction of background

To subtract a constant from an array on disk

```
FIND filename
n SUBBKG
```

Subtracts n from array 'filename'

To subtract the average value, (provided the value of BKG is zero)

```
FIND filename SBAR NUM @ SUBBKG
```

[4.8.3] Normalization of arrays

For example, for removing variations due to photocathode sensitivity on an electronograph, divide scan array by scan photocathode map and multiply through by average of latter scan.

Suppose first scan is in a disk file called STAR, the photocathode map in a file called SKY, and you wish to place the result in a file called FINAL, which you first need to create with size equal to those of STAR and SKY, starting at block n.

```
LISTFILE
```

See [4.7.4] for details.

```
FIND STAR
```

Makes disk current image with STAR's parameters.

```
n CREATE FINAL
```

Enters FINAL in index file with parameters equal to STAR.

```
FIND SKY SBAR AVERAGE VALUE = 952
```

Stores average value of SKY by NUM.

```
FIND STAR SOURCE FIND FINAL
DESTINATION
FIND SKY DIVIDE PASS
```

Divides STAR by SKY.
Multiplies through by NUM and puts the result in FINAL.

To do further DIVIDE's with NUM at the default value

```
1ØØØ NUM !
```

a b A*/ filename	Multiplies array 'filename' by a/b
m n ρ κ a b W*/ filename	Sets window of 'filename' to be m n ORIG, ρ κ WW and multiplies this window by a/b (See [4.11])

[4.8.4] NOTES

(i) If you wish to use only part of the image, ie. a subset of window, see notes in windowing in [4.11].

(ii) Words like ADD, DIVIDE, SUBTRACT do not do anything themselves except assign an operation called PROCESS which is executed for each row in PASS. At the end of a PASS, a default operation which does nothing is re-assigned so that subsequent PASSes will not perform any operation. This default operation is called NOTHING; using it immediately after ADD, etc. will cancel the effect of the latter.

These words also assign the current image to be the OPERAND (they include the word SECOND.)

[4.9] REMOVAL LOAD/SLICING LOAD

SLICING OPT LOAD loads basic display and defect removal routines. (disk files only)

REMOVAL LOAD loads the above, plus routines to

(1) Makes PDS move to appropriate location for direct visual examination of defects.
(2) Make available a file of defect coordinates.
(3) Fit gaussians to scan lines.

If you only want the basic SLICING routines	SLICING OPT LOAD	Loads limited options.
Go to [4.9.1]		
Otherwise, for REMOVAL routines	REMOVAL LOAD	Loads complete package
Go to [4.9.1] , continuing through to [4.9.2]		

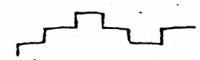
To view an array line by line.

FIND filename	Select appropriate disk file.
FIRST	Displays first line, sets graphics scalings and sets row no, R to Ø.
N	Displays next line. Repeat N for consecutive lines clearing pages as required.

If response is OK with no lines plotted, file is complete.

Otherwise, continue, or repeat N

Subsidiary Display words are:

PLOT	Replots current line. Useful after clearing page.
n DR	Skips n lines.
n RR	Plots line n
m n X SIZE	Resets X-scale so that pixels $m \leqslant i \leqslant n$ are plotted.
m n Y SIZE	Resets Y-scale so that density values m through n are plotted. (Default; 0 4000)
POINTS	Sets Plotting mode +
HISTOGRAM	Sets Plotting mode 
FOLLOW	Sets Plotting mode  Default

[4.9.1.1] To remove defect, plot line and

FIX
Position cursor on L.H.S. of defect
Tap any key (except RETURN)

Puts up cursors

	Position cursor on R.H.S. of defect Tap key	Program does linear interpolation between 2 points. New interpolated line is stored in the disk file and replotted on screen. Old line is lost.

These are all the available words in SLICING
If you have loaded REMOVAL continue to [4.9.2]

[4.9.2] REMOVAL

This assumes that source of disk file is still on PDS and coordinate system has not been changed (except for section [4.9.2.4])

[4.9.2.1]

	Plot lines until possible defect appears	If desired clear page and PLOT
If you wish to enter removed-defects co-ordinate into DEFECTS file to initialize that file then	?DEFECTS (cr) (cr)	Displays cursor and contents of DEFECTS
	LINK-CLEAR	Initializes file
Continue		
Otherwise	NOX	Puts up cursor
	Centre cursor over apparent defect	This position is not used in any subsequent defect removal and hence position of cursor is not critical.
	Tap any key (except RETURN)	PDS will move to co-ordinate corresponding to that point and the user may decide from visual appearance of area whether removal of feature is desired.

	If defect to be removed go to [4.9.2.2] Otherwise go back to [4.9.2.1] and locate another defect candidate		
[4.9.2.2]	If defect to be entered into DEFECTS file go to [4.9.2.3] Otherwise use FIX as described before in [4.9.1.1]		
[4.9.2.3]		NIX	Identical to FIX except, stores current PDS co-ordinates in DEFECTS file. (Do not move PDS between NOX and NIX otherwise wrong co-ordinates will be entered.)
	To view DEFECTS file	?DEFECTS	Defects are entered sequentially numbered after last defect in file.
	To remove further defects go to [4.9.2.1]		
	If a second plate is then set up using ALIGN so that the co-ordinate translation has been calculated using ROTATE	n @DEFECT	This will move PDS to position corresponding to coordinates in record n of defects file, with the translation added. In this way the user can see if the same defects are present on different plates. If no ROTATE has been performed since loading TAYLOR then this instruction will take PDS to nth defect of existing plate.
	Otherwise, continue		

[4.9.2.4] Fitting a Gaussian to a Scan Line

Plot line by using

N (or PLOT)

APPROX FIT — Calculates 1st approximation and does least squares fit.

CURVE — Plots fitted curve.

RESULT — Outputs values of parameters XØ (value in column CENTER) is distance from center of curve in units of 1/10 μ (ie. if result is x, pixel number in line is $x/10\delta x + \kappa/2$ where κ is pixel length of row)

CENTERING

CENTER	PEAK	BASE	HW
1.52	3ØØØ	257	3.42
Ø.ØØ	Ø	Ø	Ø.ØØ
Ø			

PEAK Is height of the peak above the base.

BASE Is the base. Units for these are the same as the scan data ($Ø \leq$ density ≤ 4095)

HW Halfwidth, units 1/10 μ. Second line gives residuals

Repeat FIT, CURVE, RESULT as required, for example:

FIT CURVE FIT FIT CURVE FIT RESULT CURVE etc.

[4.10] CONTOUR PLOTS

CONTOUR LOAD

FIND filename — Selects disk image to be plotted.

..If only a part (window) of the file is to be plotted, see [4.11] to do this

..Otherwise, continue

..Either

XWIDTH — Sets size of picture

..or

SCREEN n WIDTH — Where n is pixel width of screen

n SPACE ! — Optional: default 1ØØ
Sets contour interval to be n (ie. difference of n in the numbers in the

[4.10.2] Contour plotting directly from tape

If windowing is desired, see [4.11] , then go to [4.10.3]

Otherwise continue

[4.10.3]

low high CLIP

DISK PLOT

512 MAXIMUM SCANSALOT LOAD
CONTOUR LOAD

n SKIPS T~~WIDE~~ SET

SCREEN n WIDTH

n SPACE ! low high CLIP

TAPE PLOT

array.)

Optional: default - 32768 32767 CLIP "low" and "high" are numbers defining cutoff points, for example 200 4000 CLIP will treat all numbers < 200 as 200, and all > 4000 as 4000.

Plots contour map

This unloads TAYLOR so if you subsequently wish to use programs in TAYLOR you must repeat TAYLOR LOAD.

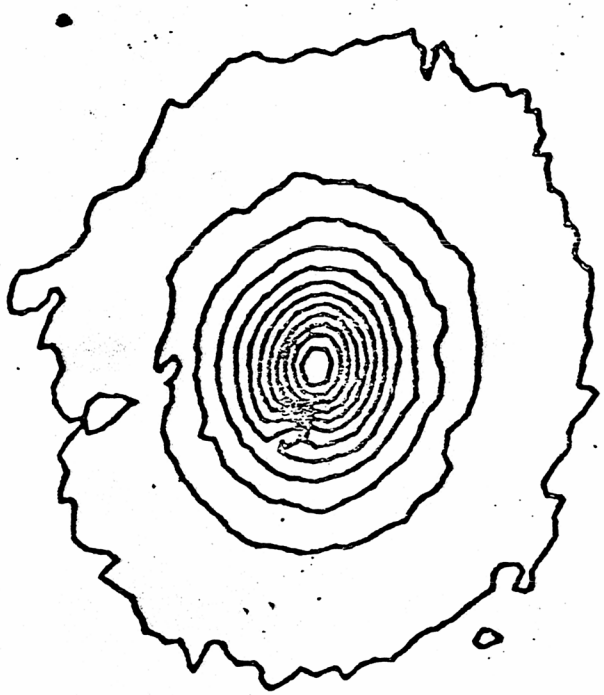
Select tape file; described in [4.12]

Described in [4.10.1]

" " "

Plots contour map.

```
9 1200 CLIP 100 SPACE ! DISK PLOT
```

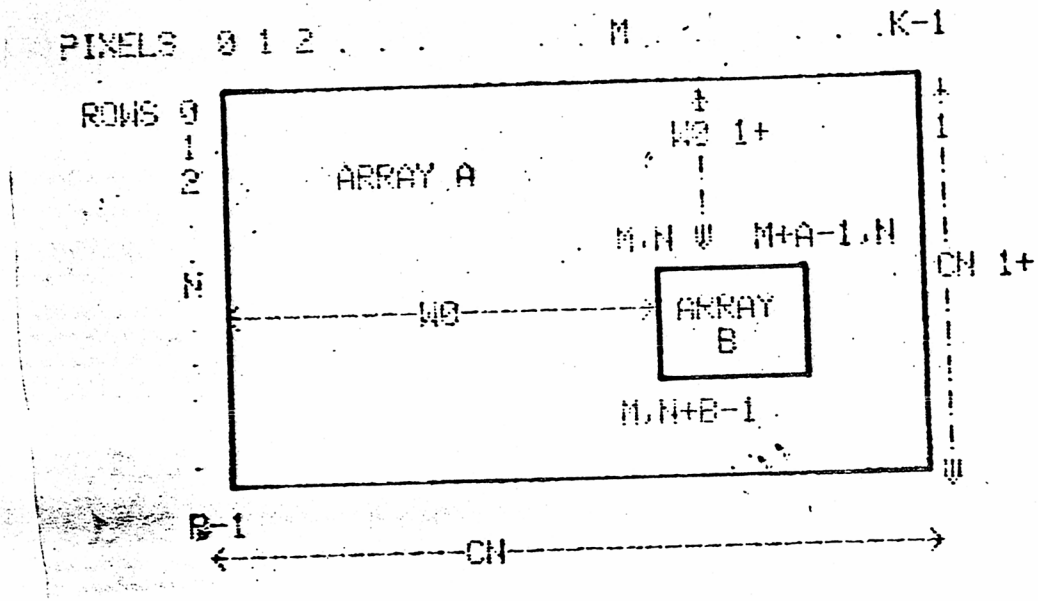


OK

Example of a PLOT using CONTOUR

[4.11] Disk file manipulation

[4.11.1] Windowing



Given a 2D array Aij of pixel dimension $\rho \times \kappa$ (such that $0 \leqslant i < \kappa$ and $0 \leqslant j < \rho$) a subset Bij of pixel dimension a x b (such that $m \leqslant i < (m + a)$ and $n \leqslant j < (n + b)$ may be accessed, provided m and $n \geqslant 0$, $(m + a) < \kappa$ and $(n + b) < \rho$.

This is used for plotting part of a large array, combining part of an array with a smaller array fitting a function to part of an array, etc..

Windowing words are:

n m ORIG	Sets $\widetilde{W\emptyset}$: defines window origin at row n, pixel m.
b a WW	Sets $\widetilde{WN}$; defines size of window to be b rows of a pixels each.
FULL	Sets $\widetilde{W\emptyset}$ to (0,0) and $\widetilde{WN} = \widetilde{CN}$ ie: makes the window the default value, the whole array.

	59	60	61	62	63	64	65	66	67	68
50	541	554	554	555	554	551	541	551	564	540
51	554	567	562	562	569	570	575	568	565	559
52	567	576	572	591	592	586	587	588	580	584
53	586	592	605	647	635	611	609	607	602	592
54	595	620	642	655	665	655	654	647	632	620
55	634	656	684	691	710	717	717	695	676	655
56	672	700	726	742	765	775	776	764	738	701
57	721	755	788	823	845	836	839	838	794	744
58	752	810	868	917	946	945	933	908	860	797
59	833	884	956	1030	1077	1100	1047	995	937	858
60	808	976	1077	1177	1245	1265	1204	1104	1015	914
61	945	1062	1135	1310	1430	1440	1363	1220	1082	960
62	993	1116	1290	1470	1591	1581	1475	1300	1133	988
63	1263	1152	1346	1532	1665	1663	1516	1326	1154	996
64	993	1162	1333	1500	1649	1614	1473	1295	1118	980
65	965	1109	1260	1397	1405	1455	1356	1211	1064	939
66	932	1037	1035	1048	1242	1276	1203	1093	979	877
67	856	935	891	835	1043	1099	1053	996	914	820
68	739	856	910	955	979	962	927	894	831	760
69	743	791	829	853	859	851	830	795	759	710
70	703	735	758	769	784	770	755	729	702	671
71	665	692	694	705	726	720	699	681	660	644
72	627	647	652	666	676	669	651	644	629	612
73	603	611	617	621	623	625	616	611	596	582
74	582	583	588	595	594	585	587	579	570	549
75	562	564	559	567	567	559	563	565	557	547
76	550	549	546	548	549	548	542	549	546	536
77	537	541	537	541	540	528	527	527	532	532
78	525	529	528	531	528	518	516	517	516	519
79	511	509	516	518	521	513	513	511	509	505

OK

Example of VCILA

[4.11.2] Digital Display

FIND filename m n VOILA	Clears page and displays window of file with origin at pixel n, row m. Resets WØ, WN to previous values at end

[4.11.3] Examples of Copying Files

FIND (file 1) SOURCE FIND (file 2) DESTINATION PASS	Copies (file 1) to (file 2)
FIND (file 1) 32 32 WW SOURCE FIND (file 2) 32 32 WW DESTINATION PASS	Copies "top left" (1st 32 pixels of 1st 32 rows of file 1) to corresponding area of file 2.

[4.12] SCANSALOT LOAD

****
* These commands are also available in BIGSCAN (See [3]) *
****

[4.12.1] To set up parameters for a scan to tape, go to [4.7.1]

If a tape is a new tape (no files on it to be kept)	
REWIND	Rewinds tape, and intialize tape variables.
NTP	Writes 1 dummy record and 2 filemarks then backspaces twice. The record is for compatability with RTSCAN tapes which have no filemark before the first file.
Go to [4.12.2]	
Otherwise ensure tape is positioned at some point before the final double filemark. Program will look for a double filemark before starting to write.	

[4.12.2] Then

WRITE identifier (cr)

Identifier is a string of ⩽ 40 characters (including spaces). Tape will run forward until a double filemark is found, and will then backspace so that the second filemark will be overwritten. The scan will be performed using the PLATE parameters set previously. The data will be written onto tape in Scansalot format.

After the scan is completed, a double filemark will be written at the end of the file, and the tape will then be backspaced twice, so that a second WRITE will not require any repositioning of the tape.

The rest of this section [4.12] can be used without doing a TAYLOR LOAD, by doing a 512 MAXIMUM SCANSALOT R-X instead.

[4.12.3] Disk-to tape pass

FIND filename

Selects appropriate disk file

WRITE identifier

Looks for end of tape (double filemark) backspaces once and copies disk file onto tape. Finishes by writing a new double filemark and backspaces twice.

Identifier is ⩽ 40 character string including spaces terminated by carriage return.

[4.12.4] Tape positioning (word definitions)

n POS

Immediately after loading, the computer does not know the current position of the tape, so if the tape is not at the beginning, you must tell it which file number it is at, using the command POS.

```
T-INDEX
 0 DUMMY FILE ;  BEGINNING OF TAPE
 1 JCM TEST SCAN 1978JUL26
 2 VERTICAL SCAN, ODD=1
 3 ANOTHER VERTICAL SCAN
 4 SIMPLE SCAN
 5 AUWRITE TEST

 END OF FILES OK
```

2	1	0	0	0.	0.
64	64	10	10	-26860.	-3398.
20	32	-12	-5	-14010.	-11834.
20	32	-12	-5	-14010.	-11834.
64	64	10	10	-26860.	-3398.
64	64	10	10	0.	0.
wN	wN1+	0x	0x1+	c0	c0 2+

Example of T-INDEX

REWIND	Rewinds tape, initializes tape variables EOFS and REC.
n SKIPS	n > Ø passes forward over n filemarks. Remains positioned immediately after the last (ie. at the beginning of a file). n < Ø goes backward over n filemarks then forward 1 space, so positioning tape at the beginning of a file. -1 SKIPS returns to beginning of current file. (Sometimes!)
SET	To be used after SKIPS (or FILE). Returns to beginning of current file, goes through file checking number of records and coordinates in header, uses these to set TAPE parameters $\widetilde{WN}$, $\widetilde{CN}$, $\widetilde{C\emptyset}$, $\widetilde{DX}$. Types first identifier returns to beginning of the file. n SKIPS SET is the taping equivalent of FIND filename for disk files.
T-INDEX	Prints directory of files on tape; rewinds tape and goes forward until double filemark found, then backspaces twice.
n FILE	Positions at end of first record of file n, n is absolute file number with dummy header file being zero. However in some circumstances when interrogating individual records in a file, one goes past the end of file. Subsequent use of FILE may give the wrong result.
LABEL	Reads and prints next records identifier
n RECS	Moves forward n-1 records and reads next record.

1 RECS reads next record
2 RECS reads next record but 1
0 RECS reads record just read
-1 RECS reads record before one just read.

SHOW

Types identifier and dumps scan data currently in working storage. To be used after RECS. (N.B. WN may be incorrect if a TWIDE has not been done on file).

[4.12.5] Tape to disk pass

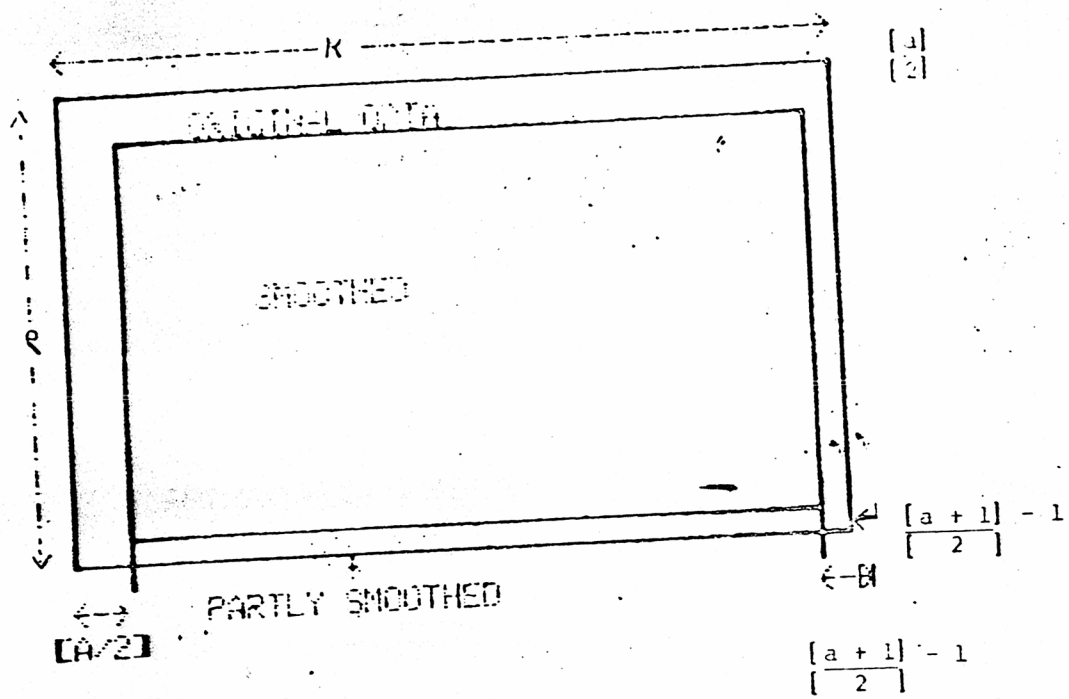
n SKIPS LABEL

Moves n filemarks then prints identifi of first record (to check if file is correct one).

If disk array not yet allocated, use LISTFILE or n m LISTB to examine images index and then create file by n CREATE filename, as explained in [4.7.2]

TDPASS filename

Copies tape file to disk file 'filename'.


K
[a/2]
SMOOTHED
PARTLY SMOOTHED
[A/2]
[a + 1] - 1
[2]
[a + 1] - 1
[2]

[5] SMOOTHING (boxcar convolution)

[5.1]

Averaging in i and j by constant factor a; disk arrays only.
Description:
Let contents of pixel i, row j in array A be Aij
A is source array, B is smoothed array
Each array consists of ρ rows of κ pixels each
$[\chi]$ means integer part of χ

Action of program:

Bij = Aij for (i) $\emptyset \leq j < [a/2]$, $\emptyset \leq i < \kappa$

(ii) $\emptyset \leq j < [a/2]$, $\emptyset \leq j < \rho$

(iii) $\kappa - [(a+1)/2] + 1 \leq i < \kappa$, $\emptyset \leq j < \rho$

Partially smoothed s.t. $Bij = (a(\rho - j + [a/2]))^{-1} \sum_{\ell = j-[a/2]}^{\rho-1} \; ; \sum_{k=[i-a/2]}^{i+[(a+1)/2]-1} A_{k\ell}$

for $[a/2] \leq i < \kappa - [(a+1)/2] + 1$; $\rho - [(a+1)/2] + 1 \leq j < \rho$

Smoothed s.t. $Bij = a^{-2} \sum_{\ell = j-[a/2]}^{j+[(a+1)/2]-1} \; ; \sum_{k=i-[a/2]}^{i+[(a+1)/2]-1} A_{k\ell}$

for $[a/2] \leq i < \kappa - [(a+1)/2] + 1$, $[a/2] \leq j < \rho - [(a+1)/2]$

Inside fully smoothed region:

For odd values of a - Bij is the average of the a x a square of points in array A with center (i,j)

For even values of a- Bij is the average of the a x a square of points in array A with center $(i - \frac{1}{2}, j - \frac{1}{2})$ so for even a

the image is translated by ½ pixel in i and j. If an array is to be repeatedly smoothed by an even factor it is recommended that the array be 'flipped' each time before smoothing so that: Aij → A(κ-i-1, ρ-j-1). Thus the successive translations will cancel instead of adding. How to achieve this is described below.

[5.2] Tape Files

This program only works on disk files. To smooth a tape file first copy it on to disk, either 512 MAXIMUM SCANSALOT LOAD or TAYLOR LOAD SCANSALOT LOAD, and then go to [4.12.5] for instructions on tape-to-disk pass.

[5.3] Loading

a SMOOTHING LOAD	a is the full width of the boxcar in ρ and κ (a ⩾ 2).

[5.4] Disk files

Allocate all disk files you will require using

LISTFILE	Lists images index; for explanation see [4.7.2]
FIND file 1	Sets current image parameters to those of file 1. file 1 is the source file ie. the one you wish to smooth.
n CREATE filename	n is block number, select as described in [4.7.2]. CREATE allocates a file called filename the same size as file 1. Use CREATE to allocate all the files you will need.

[5.5.] Smoothing

(i) Single smoothing

```
FIND  file 1  SOURCE
FIND  file 2  CONVOLUTE
```

Defines file 1 as the INPUT file, ie. file to be smoothed.

Copies file 1 to file 2 and smooths file 2. CONVOLUTE is equivalent to DESTINATION PASS $CONVOLVE (see below).

(ii) Smoothing into same file

```
FIND  file 1  $CONVOLVE
```

Smooths file 1 , overwriting original data. If you wish to save original data, copy it into another file or use CONVOLUTE as in (i) and then FIND file $CONVOLVE.

```
FIND  file 1  $CONVOLVE $CONVOLVE $CONVOLVE
```

Repeatedly smooths file 1

(iii) Flipping and then smoothing, for use with repeated smoothing by even values.

```
FIND  file 1  SOURCE
FIND  file 2  RCONVOLUTE
```

file 1 will be overwritten later, to save original first copy it.

Copies file 1 to file 2 reflecting it on the way so that pixel (i,j) of file 1 is put in pixel (κ-i-1, ρ-j-1 of file 2 ie. reflected in the centre point of the array.
Then smooths file 2

```
SOURCE FIND  file 1  RCONVOLUTE
```

Flips file 2 into file 1 and smooths file 1

```
SOURCE FIND  file 2  RCONVOLUTE
SOURCE FIND  file 1  RCONVOLUTE
SOURCE FIND  file 2  RCONVOLUTE
```

Repeatedly smooths array, with the $\frac{1}{2}$-pixel translation caused by each smoothing cancelling.

If the final file is (file 1), the array will be the right way round, if it is (file 2), one more flip must be done to correct it.

For example

```
SOURCE FIND file 1 RC-FLIP          Takes current file, flips into file 1
DESTINATION PASS
```

[6] 3D plot

There are 3 variants of the 3D plotting routine

..Either 3D LOAD Loads basic FORTH 3D plot.

..or 3DH LOAD Loads hidden line 3D plot.

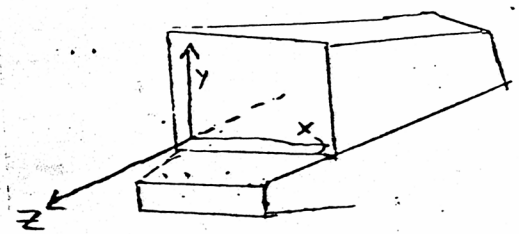
..or 3DJ LOAD Loads alternative hidden line plot.

..If disk files to be plotted go to [6.1]

..Otherwise, if tape files are to be plotted SCANSALOT LOAD Loads taping routines.

[6.1] Form of plot

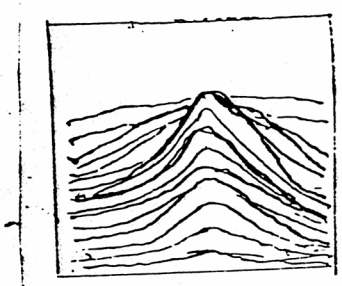
Orientation of axes



X represents pixels/row

Y represents density units (numbers in array)

Z is direction of decreasing row number ie. later rows are plotted towards the more negative Z.



z = 0

row zero, Z = ρ - 1

To set the X scale	n m X SIZE	n is the abscissa of the LHS of the screen. m is the abscissa of the RHS.
Thus	Ø WN @ X SIZE	will cause a plotted row to fill the screen from left to right (WN @ gives value of κ).
	n m Y SIZE	set the Y scale.
	n m Z SIZE	controls spacing between rows.
Default values:	Ø 32 X SIZE	
	Ø 8192 Y SIZE	
	- 64 64 Z SIZE	

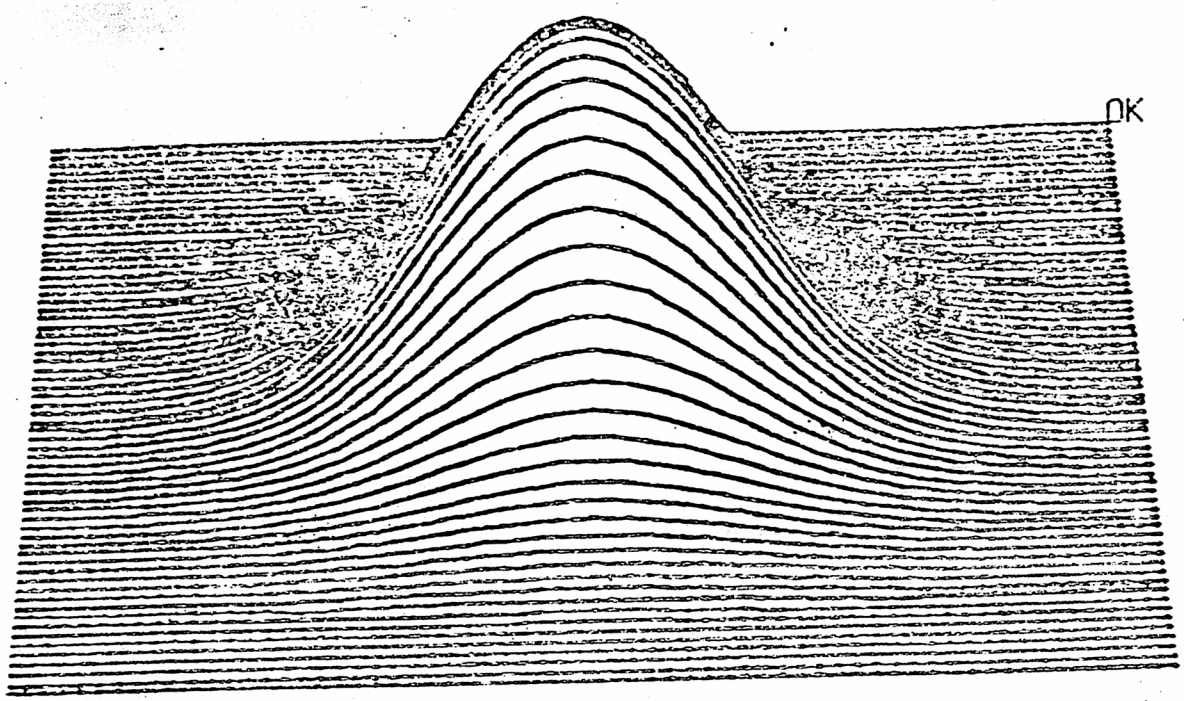
The pitch and yaw of the image can also be altered.

Pitch inclines the Z axis from the horizontal.
Yaw inclines the Y axis from the vertical, in the plane normal to Z.
Default pitch is 6Ø°, yaw is zero.

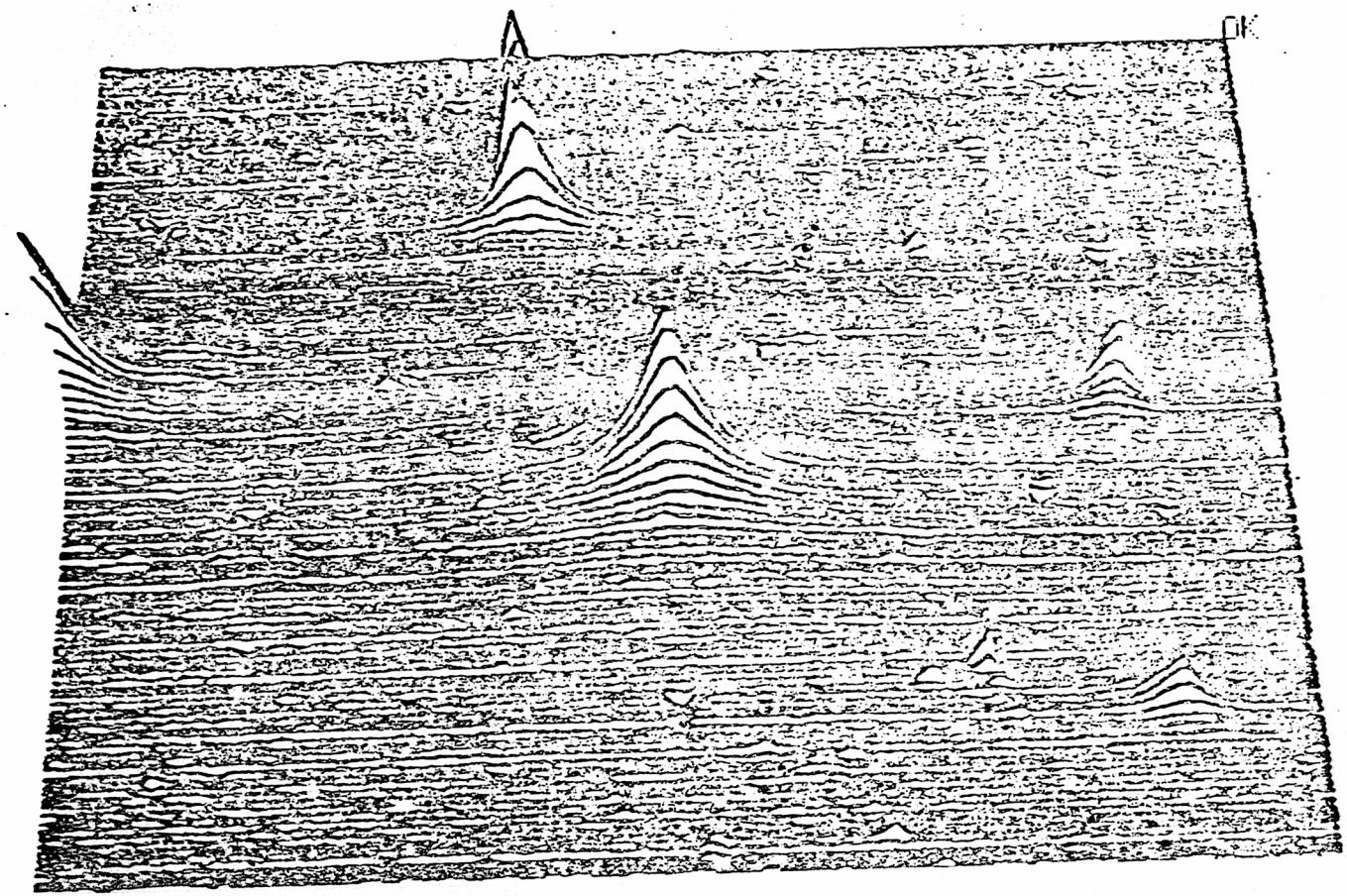
[6.2] Commands

Commands for the three variants are identical except in the case of PITCH and YAW.

	SCREEN ρ k WIDE	No more than ρ rows and no more than κ pixels/row will be plotted.
Either for a disk file	FIND filename	Selects disk file to be plotted.
or, for a tape file	n SKIPS SET	n is relative file number; see [4.12] for explanation.



a PLOT using 3DSLOW



[6.2.1] Then for Disc or Tape

..If only part of file to be plotted	n m ORIG	see [4.11] for explanation.
	b a WW	see [4.11] for explanation.
Continue		
..Otherwise, continue	n m X SIZE	Sets up X axis co-ordinates. n = abscissa of L.H.S. m = abscissa of R.H.S. (Default 0 32 X SIZE)
	n m Y SIZE	(Default 0 8192 Y SIZE)
	n m Z SIZE	(Default -64 64 Z SIZE) For explanation see [6.1]
..If 3D variant being used	s c PITCH	Default 866 500 PITCH
	s c YAW	Default 0 1000 YAW s = 1000 sin θ c = 1000 cos θ
Go to [6.2.2]		
..Otherwise (ie. 3DH or 3DJ variants).	nn.nn PITCH	Default 60.00 PITCH, nn.nn is angle in degrees. There must be exactly 2 decimal places - do NOT omit trailing zeros.
	nn.nn YAW	Default 00.00 YAW
[6.2.2] ..If a disk file then	PLOT	Clears page, plots file.
Go to [6.2.3]		
..Otherwise for a tape file	TAPE PLOT	Clears page, plots file.

[6.2.3] To replot using different window, scales, pitch or yaw: go to [6.2.1]

Description: Least squares fitting of a 2-D gaussian to scan data from a disk file. The file may be windowed (see [4.11]).

Consider a 2-D array of data Aij where $0 \leqslant i < \kappa$ and $0 \leqslant j < \rho$

Fitting Parameters

XØ = 6400i/κ

YØ = 6400j/κ.δj/δi

where (XØ, YØ) is centre of gaussian and δj/δi = ratio of sample intervals in microns of the j and i direction.

PEAK = Height of peak above base (units as in Aij)

BASE = Base (units as in Aij)

HX = Half width at half height in i direction (units as in XØ)

HY = Half width at half height in j direction (units as in YØ)

SR = Correlation. Stored as integer. Value multiplied by 1000.

Function:

$$f(i,j) = (BASE) + (PEAK).2^{-\xi} \leqslant C$$

where; $\xi = \left[\frac{X - X\emptyset}{HX}\right]^2 + \frac{SR(X - X\emptyset)(Y - Y\emptyset)}{HX.HY} + \left[\frac{Y - Y\emptyset}{HY}\right]^2$

X = 6400i/κ ; Y = 6400j/κ.δj/δi

C = cut-off value. (Default 4095)

[7.1] To initiate PHOTOMETRY

PHOTOMETRY LOAD

Loads relevant programs

[7.2]

n CUTOFF !

Sets n to be cutoff value. Default; n = 4Ø95

FIND filename

Selects disk file

..If windowing required, see [4.11], then go to [7.2.1]

..Otherwise, continue

[7.2.1]

APPROX

Calculates a first approximation

[7.2.2]

FIT

Performs the fit

RESULT

Outputs the result

PHOTOMETRY

XØ	YØ	PEAK	BASE	HX	HY	SR
16.ØØ	16.ØØ	3ØØØ	2ØØ	8.ØØ	8.ØØ	Ø.ØØØ
Ø.Ø1	Ø.Ø3	14	2	Ø.23	Ø.Ø4	Ø.ØØ7
48						

XØ, YØ, HX, HY output in pixel units. Residuals; related to covariance matrix $\sqrt{S^2}$ where S^2 is sum of squared deviation $\sqrt{\rho k-7}$ of previous fit.

Loop to [7.2.2] until residuals are sufficiently small.

4 FITS are usually enough; a single FIT takes about 3 mins. for a 32 x 32 file, 9 mins. for a 64 x 64 file.

[7.3] Creating "Faked" Gaussians

To create a file containing a digitized gaussian which has been defined by a FIT, immediately after FIT or RESULT

To change cutoff value

c CUTOFF !

32767 CUTOFF ! gives c its maximum value.

If you wish to overwrite the fitted data in a file by its fitted gaussian	FAKE	For every point in the file the function is calculated and the value stored in that point of the array.
Finish		
Otherwise create a new file by	LISTFILE	Explained in [4.7.2]
	n CREATE file 2	" " "
	FIND file 2 FAKE	Puts gaussian in file 2

[7.3.1] Test gaussians

These can be created by setting up the appropriate parameter values as follows:

To define gaussian parameters	FIND filename	Selects file
Either	x_o RSU XØ !	
	y_o UM YØ !	x_o, y_o, h_x, h_y in pixels
	h_x WØ @ RSU HX !	
	h_y WØ 1 + @ + RSU HY !	
or	x_o XØ ! y_o YØ !	x_o, y_o, h_x h_y in scaled units described at the beginning of [7]
	h_x HX ! h_y HY !	
Then	p PEAK ! b BASE ! r SR !	Sets PEAK, BASE, SR; where r = correlation x 1000
To check the above entries	RESULT	Ignore 2nd and 3rd rows of output

To add normally distributed noise s SD !

Multiples each value to be stored in the array by [1 + δ(s)/1ØØØ] where δ(s) is normally distributed between ± 3s with mean zero.

Then FAKE

Creates gaussian, stores in disk file.

[7.4] Graphic Display of Fit

After fit is complete, you may use all the commands in SLICING (except FIX) to display the file, and also the command CURVE which plots the fitted line corresponding to the current line plotted. The command XC goes through the whole file doing FIRST CURVE N CURVE N ..... etc, clearing the page between each row, thus allowing you to view the goodness of fit of the whole file.

[8] Additional Facilities

[8.1] Multiple scans

Capability to set up for a number of scans to tape as in BIGSCAN, but instead of doing each scan before setting up for the next, store the parameters of each scan in a file called SCANS file. A single instruction will then cause all the scans to be done in turn.
Max. no of scans allowed is 79.
The following parameters may be different for each scan:

The entire "image parameter field": $\widetilde{CN}$, $\widetilde{DX}$, $\widetilde{C\emptyset}$, $\widetilde{W\emptyset}$, $\widetilde{WI}$, KIND

ie. **(i)** size of scan, set by WIDE (or DIM)

(ii) sample intervals, set by DXDY !

(iii) origin, set by either CENTER or c CORNER where c is UR, UL, LL or LR. Scans may be identified by different corners.

(iv) direction of scan, set by VERTICAL or HORIZONTAL.

and also

(v) the Scansalot 4Ø-character identifier

(iv) whether the scan is averaged or not, and by how much

[8.1.1] BIGSCAN LOAD 428 LOAD

CLEAR clears scans file

Go to [3.2] to
Set up PDS for first scan
(ie. MM/S, WIDE, etc.)

[8.1.2] ..Either	n ENTER identifier	n is scan number (1 for first scan) Enters parameters and identifier in file.
: : : : : :..or	a n A-ENTER	a is value to be averaged by ($= 2^n$) in x and y
	Set up PDS for $(n + 1)^{th}$ scan	
Then		
..Either	HORIZONTAL	Default
: :..or	VERTICAL	
: :..or nothing if previous scan was the same direction		
	ρ κ WIDE	omit if same as previous scan
	δx δy DXDY	" " " " " "
Then		
..Either	CENTER	After positioning PDS over appropriate point
: : : :..or	UR (or UL, LL, LR) CORNER	After positioning PDS over appropriate point
: : : :..or	y. x. $CENTRE (or $CORNER)	See [4.3]
Then Loop to [8.1.2] incrementing n by 1 each time until all scans ($\leqslant$ 16) have been entered		
..If tape is a new tape : Go to [8.1.3]	REWIND NTP	see [3.3] for explanation
: :..Otherwise position tape anywhere before end of double file mark		

[8.1.3]	Then	SCAN	Does each scan in turn, writing onto tape, with the appropriate parameters with a filemake between each scan and two at the end.
		CLEAR	Clears scans file for next user.

[8.2] Array flipping

Capability to flip data in an array on disk:

in i : flips each row end for end
in j : flips each column end for end; or in both i and j

[8.2.1]	TAYLOR LOAD 431 OPT LOAD	Loads flipping option
Allocate file a using CREATE as in [4.7.2]		
	FIND file 1 SOURCE FIND file 2 DESTINATION	
Either	ROW-FLIP	Sets up for flip in i
or	COL-FLIP	" " " " " j
or	RC-FLIP	" " " " " i and j
Then	KEEP PASS	Updates index file and copies array from file 1 to file 2 flipping on the way.
To flip an image scanned with origin at one corner to be as if it was scanned from another, use RECTIFY	FIND file 1 SOURCE FIND file 2 UR DESTINATION RECTIFY	Copies file 1 to file 2 flipping

it appropriately to make the scan as if it was scanned from the UR corner. Using UL, LL or LR instead of UR would cause the final file to have the specified corner as its origin.

To transform an array scanned in y to one scanned in x

```
FIND  file 1  SOURCE FIND  file 2
DESTINATION TURN
```

If file 1 is A and file 2 is B, the effect of the command TURN is,

Aij becomes Bij where subscripts represent row and column numbers.

Due to the simplicity of the method, the operation is prohibitively slow for arrays >(64 by 64)

[8.3] Tape file graphic record display

This utility combines SCANSALOT with the display words in SLICING (see [4.9], [4.12]).

454 LOAD	Loads programs
n SKIPS SET	Selects tape file, see [4.12]
FIRST	Sets scales, plots 1st line. See [4.9]

The following commands are available, and are described in [4.9]

N	Reads and plots next line
PLOT	Plots current line
AXES	

	BIG GRID	
	POINTS	
	FOLLOW	
	HISTOGRAM	Define graphic options
	n m X SIZE	
	n m Y SIZE	
There is one additional command:	SAMPLE	Plots every n^{th} point of current line. n is set by n SPL ! (default 5). like PLOT, SAMPLE does not actually read a record, N must be used for that first.

[8.4] Coarse file

Description: Used most often to compare scans from an electronograph with the corresponding area on a cathode map. Disadvantage is that it is not as accurate as ALIGN but advantage is that cathode map is only scanned once, and file is reused for different higher resolution scans. ALIGN is generally used to eliminate fine variations within a single scan area while the coarse-file method is used to eliminate grosser variations across a larger area of photocathode.

The whole or a large part of the photocathode map is scanned at a coarse spatial resolution and stored on tape or disk. A second scan at a higher spatial resolution is stored on disk or tape. The program creates a third file on disk, containing photocathode map with weighted average of the 4 nearest-neighbour points in the coarse file.

[8.4.1] Creating the coarse file

Do a normal scan as in [3.2], [3.3] or [4.7.11], [4.7.2] except:
ZILCH over a standard mark common to all electronographs to be scanned, (for

example, upper left fiducial mark). In addition electronographs must be approximately aligned with one another using the fiducial marks or photocathode defects. The scan must be in X and must be specified by either the CENTER or the UR CORNER.

[8.4.2] Creating the nearest-neighbour file (from the parameters of a scan, called "source scan", done from a corresponding electronograph.

The source scan is done either onto tape or disk. The sample intervals must be less than those of the coarse file. The source scan must be in X and the origin must be defined by either CENTER or UR CORNER. ZILCH must be done at the same standard point as was done for the coarse file.

The nearest neighbour file may now be created using the data from the coarse file and the parameters of the source scan.

	BIGSCAN LOAD	
	457 LOAD	loads coarse file routines
If source scan on disk	FIND filename SOURCE	Selects source scan file
Go to [8.4.3]		
Otherwise, ie. on tape	n SKIPS SET SOURCE	Selects source scan file see [4.12] for explanation
[8.4.3] To allocate a new file in disk index, use	LISTFILE n CREATE file 2	See [4.7.2] for explanation
	FIND file 2 DESTINATION	Selects destination file
If coarse file on disk	FIND coarse-file SECOND	Sets up coarse-file parameters
Go to [8.4.4]		
Otherwise, ie. coarse file on tape	n SKIPS SET SECOND	Sets up coarse file parameters

Example of density

Example of PLOT

[3.4.4]	Then	NEAREST	Calculates and stores nearest neighbour file in file 2

To use file 2 created by NEAREST to take out effects of photocathode response from file 1 do TAYLOR LOAD PROCESSING LOAD and see section [4.8]

[3.5] Density histogram (Disk files only)

	DHIST LOAD	Loads programs
	FIND filename	Selects file
	n RES	Sets bucket resolution (default 10)
	DENSITY	Sets up array of 'buckets', goes through file counting number of points in file with densities in range of each bucket, and plots results as a histogram of number against density. The default bucket size n is 10 (minimum value is 1, an ordinate of 200 means that there are 200 points between the abscissa density value and that value + n
Data may be replotted as follows	a b ROI PLOT	Plots density values a to b only, without change of scale.
	a b SEE PLOT	Plots density values a to b, expanding scale to fill screen.
	min max Y SIZE	Sets Y scale
	ENTIRE PLOT	Equivalent to 0 4095 SEE PLOT DENSITY plots all values from 0 to 4095

[8.6] Coordinates file

A facility to store large numbers of PDS coordinates on disk

386 LOAD

LINK-CLEAR	Clears COORDS file
Z	Stores current PDS position in next record of file
y. x. P	Enters coordinates (x., y.) in next record of file
y. x. n PX	Enters coordinates (x., y.) in n^{th} record of file
D1	Deletes last record in file
n N	Prints out contents of n^{th} record
L	Lists file (follow by two carriage returns)

[8.7] Multiple output

TAYLOR LOAD CONTOUR LOAD 384 LOAD

Doing a scan from plate to disk, replacing PASS by CPLOT PASS will plot the output on the screen at the same time; NPLOT PASS will dump the numbers on the screen (you must clear the page each time it becomes full.)

[9.0] JPLOT grey-scale plot

JPLOT LOAD	Loads grey-scale plot routines; for disk files only. Max size of plot is 128 x 128 pixels.

[9.1] Setting grey levels and plotting

FIND filename	Selects file
n m ORIG	
ρ κ WW	Selects window of file as explained

The density histogram commands documented in [8.6] are available.

..Either	a b BSET	Sets grey scale levels; there are 5 levels, set to be : 1) $x \leqslant a$ 2) $a < x \leqslant a + \Delta a$ 3) $a + \Delta a \leqslant x \leqslant a + Z\Delta a$ 4) $a + Z\Delta a \leqslant x \leqslant b$ 5) $x \geqslant b$ where $b = a + 3\Delta a$
..or	a Δa LSET	
..or	a b XSET	Sets levels to be $a + n\Delta a$, $n = 0$ to 4 $\Delta a = (b - a)/5$, and ignores points outside the range (a,b)
	JPLOT	Clears page, plots image and puts identification on the side
	GR	Puts grid on picture (optional)

[9.2] Cursor facility

	CURSOR	Puts up cursor on screen:
..Either	C	Prints out on screen pixel Coordinate corresponding to cursor position
..or	P	Types out value of array at that poin
..or	S	Replots at a larger scale the Segment of the picture defined by the portion of the grid it is in (you must have the grid plotted to use this).
..or	any other key	Puts up the cursor again; move them a tap any key; the first and second points defined by the cursor are used as the lower left and upper right corners of a rectangle which is then replotted on a larger scale.

DISPLAY	Replots output on sides and grid on screen, but not picture itself. Used to select another area using the cursor without plotting the whole picture again (to save time)
DISK JPLOT	This will plot the window of the file used prior to CURSOR, whereas JPLOT will just plot the latest segment or window.

[10.0] Error conditions

If you type a command which the machine does not recognize, the machine will echo the command followed by ? and clear the push-down stack. Continue by typing in correct commands.

If you interrupt a scan to tape (by pressing Control C, then Return), the command CANCEL will move the tape back to the beginning of the file and write an extra filemark, effectively erasing the file. Note however that if you reload either BIGSCAN or TAYLOR before doing this (eg due to a system crash) the computer will not remember the current position of the tape and a CANCEL will lose the whole tape by writing a double filemark at the beginning of the tape.

The command (OFF) will send an instruction to the PDS motors cancelling any instruction to move the PDS (eg when the stage jiggles erratically after an interrupt).

FILE STAR

PIXELS
256 TO 319

ROWS
320 TO 383

LEVELS

3000

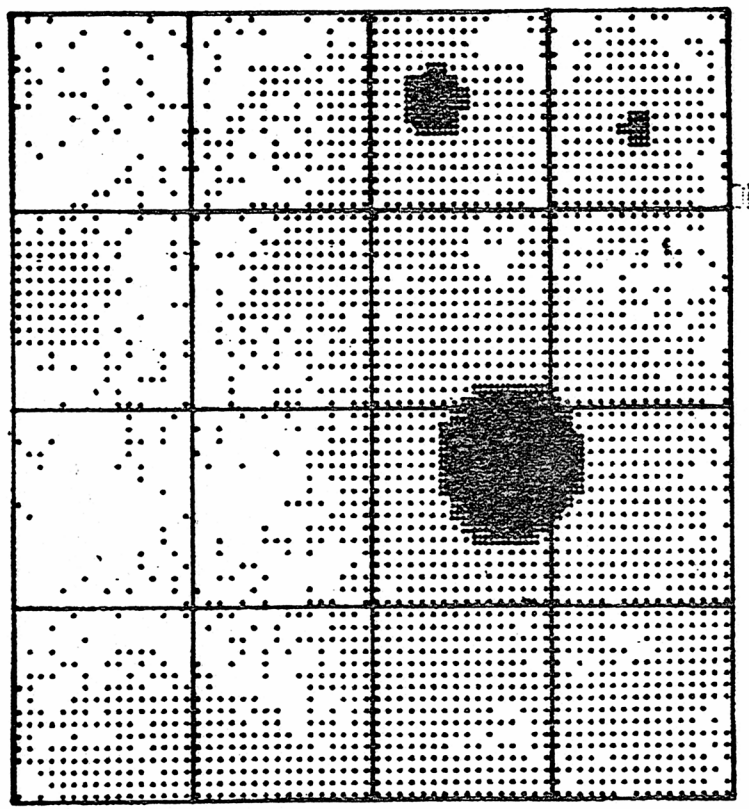
2400

1800

1200

600

0



OK

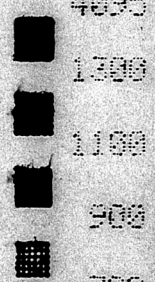
GR

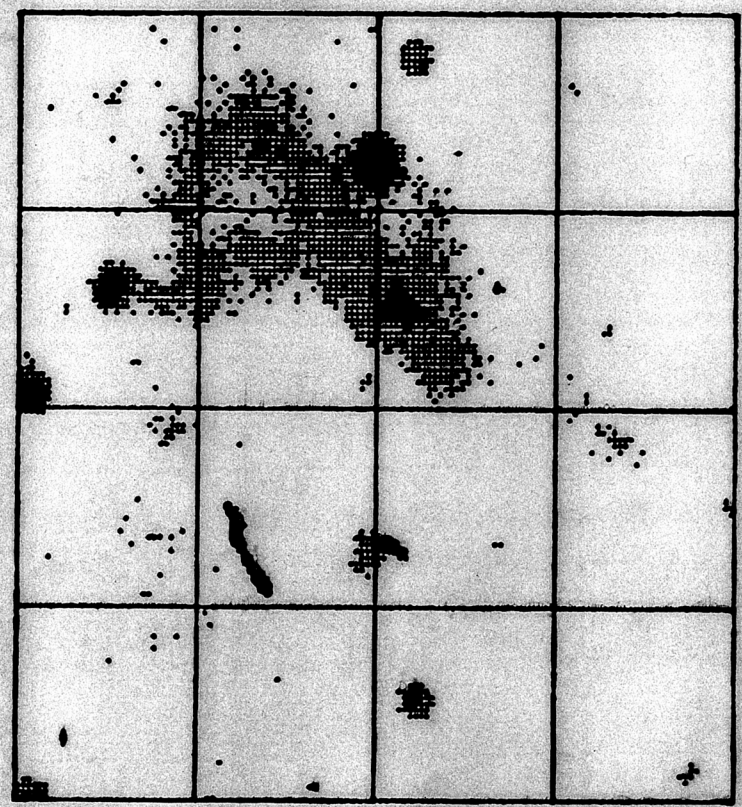
FILE RICHARD

PIXELS
220 TO 347

ROWS
30 TO 217

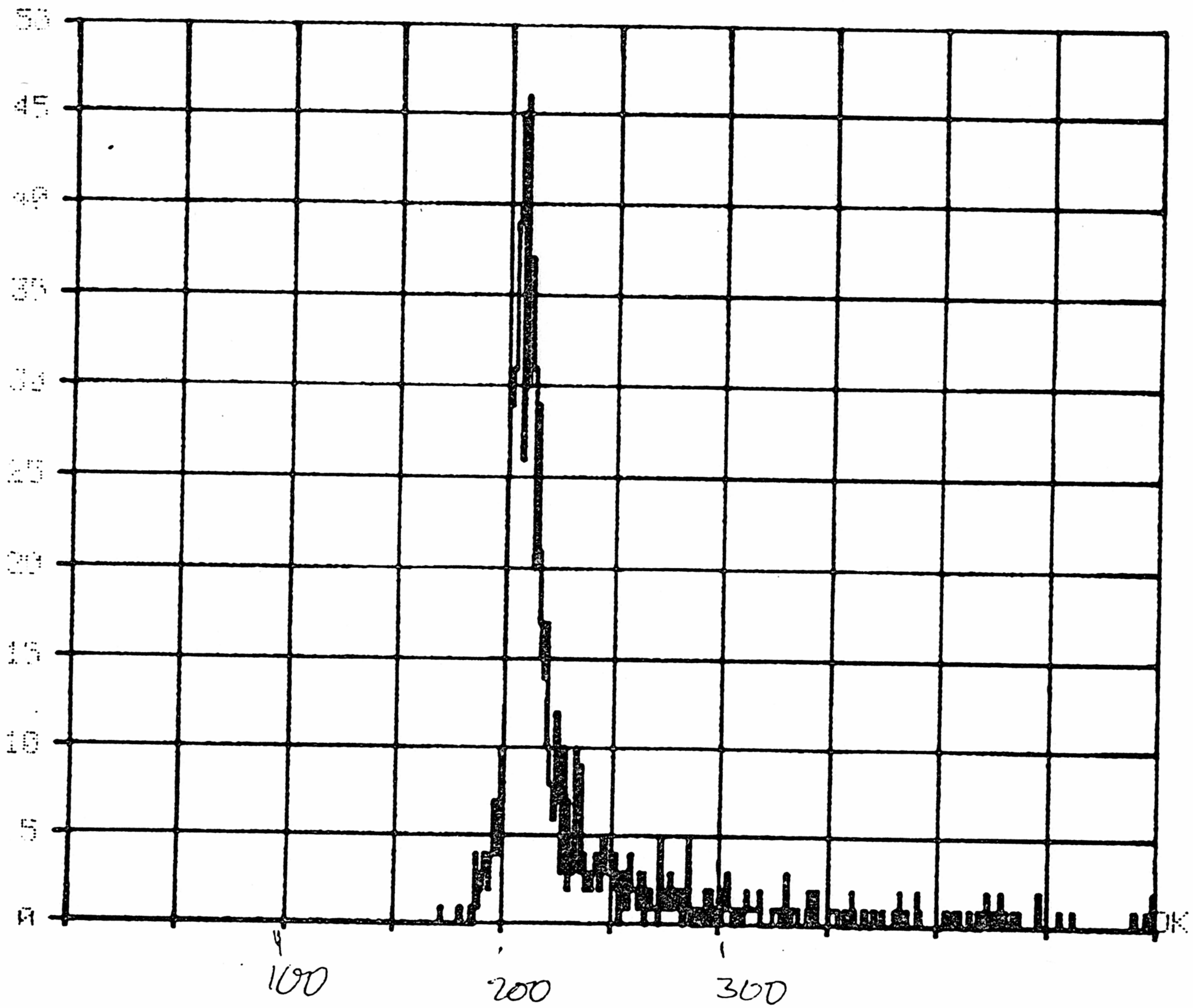
LEVELS





OK

G 50 Y SIZE PLOT



399 394 LOAD

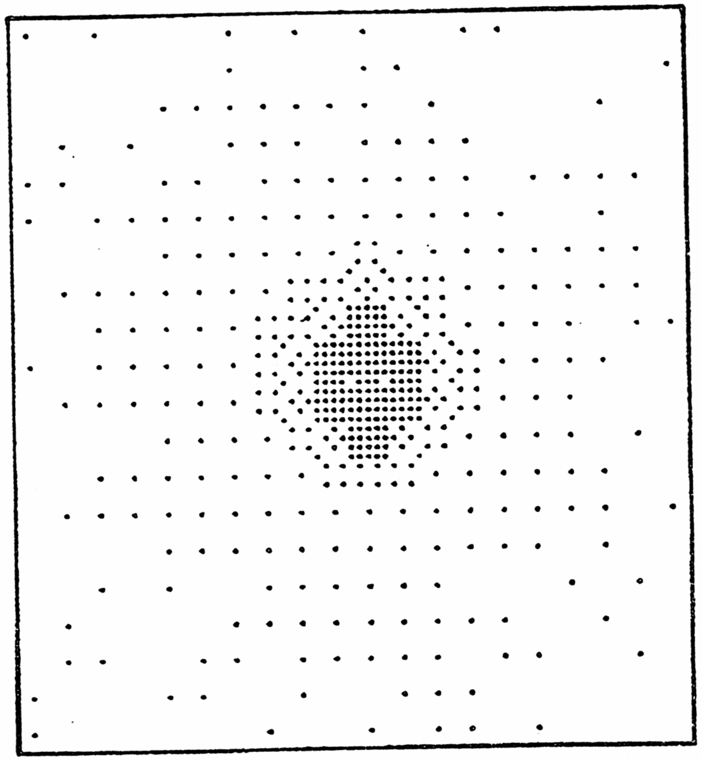
OK

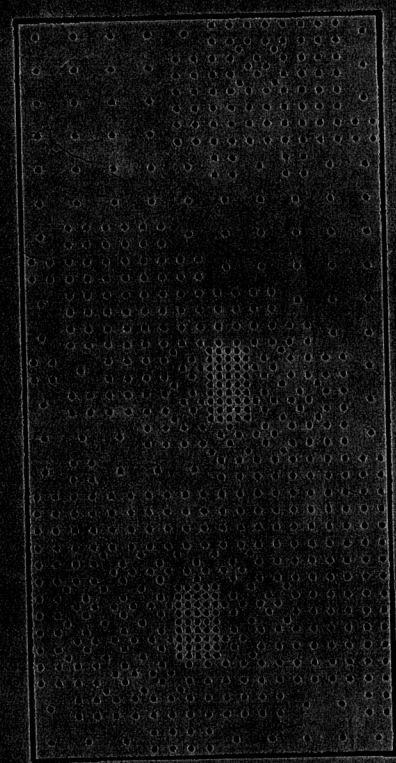
FILE 11

PIXELS
0 TO 19

ROWS
0 TO 19

LEVELS
1000
800
600
400
200
0





145 SPACE ! DISK PLOT

DON'T PANIC