Chapter 3. Geomtric Dimensioning and Tolerancing

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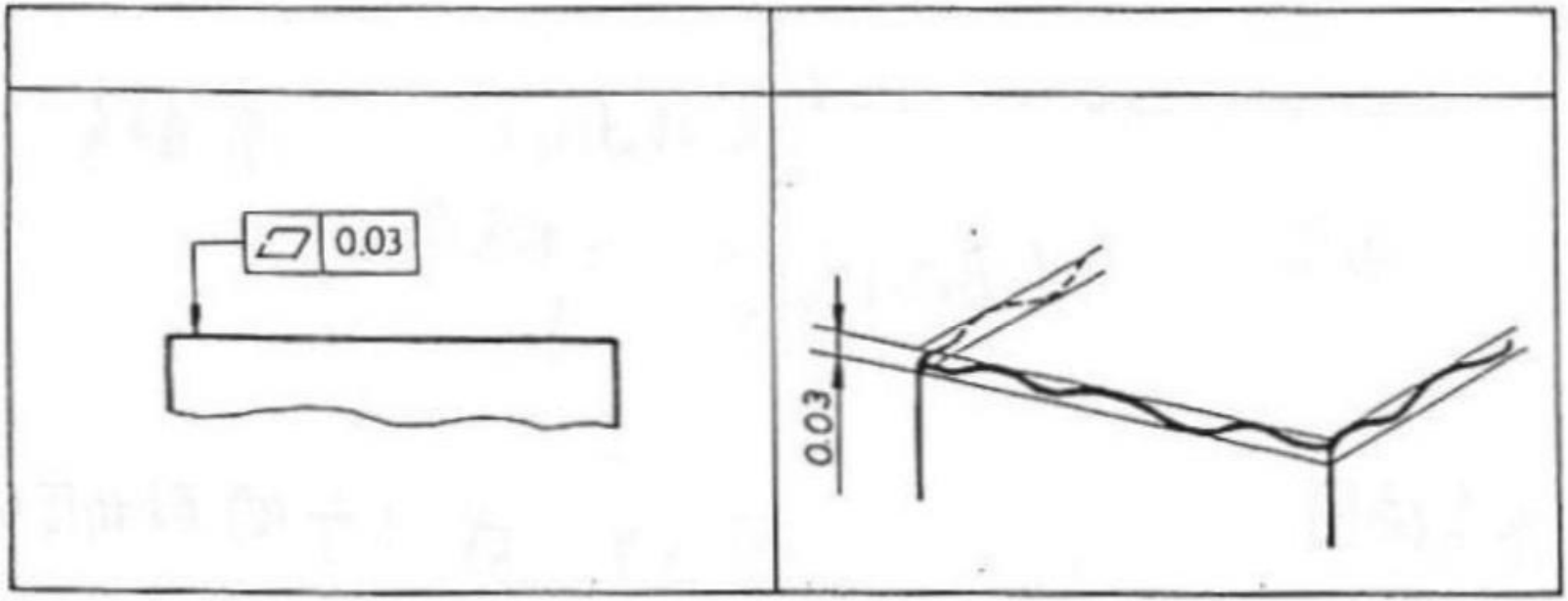
Outline

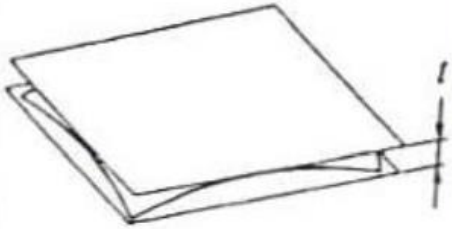
- Straightness
- Flatness
- Position Error
- Runout Error
- Journal Review

Flatness Definition

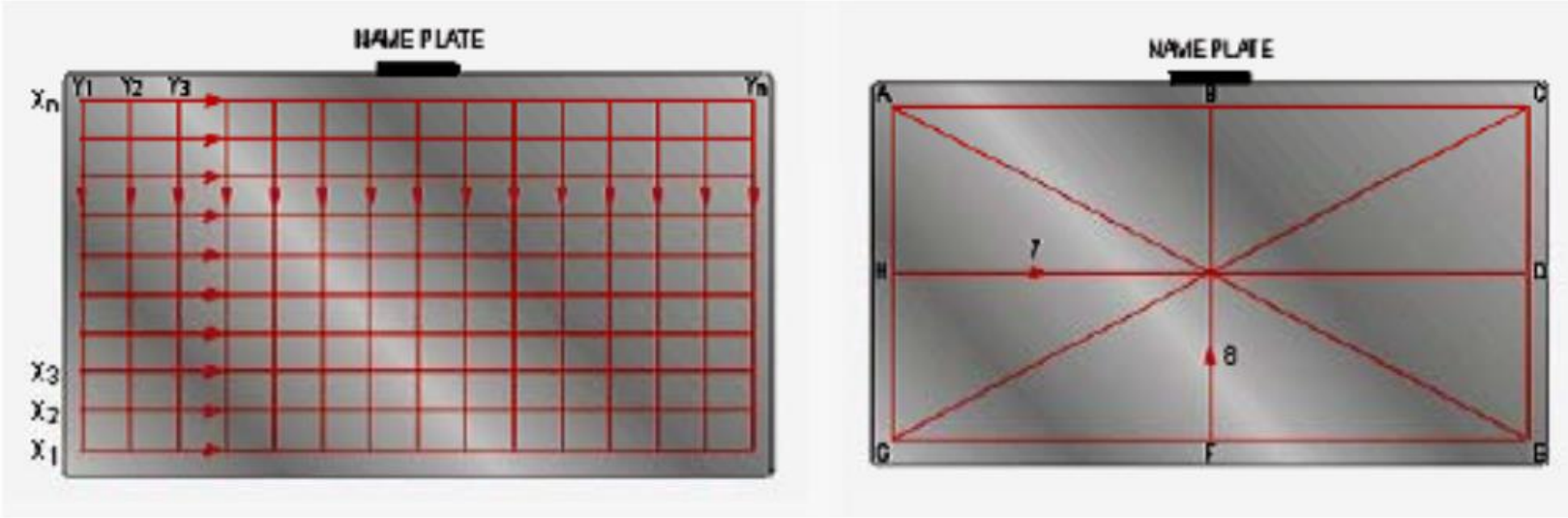


Surface Plate

Work surface	Allowable flatness error for different grades			Diagonal length
工作面尺度	工作面眞平度之許可差 (μm)			對角線長度度 (mm) (參考用)
(mm)	0 級	1 級	2 級	
250×250	2	4	8	354
400×250	3	5	10	472
400×400	3	6	12	566
630×400	4	8	16	746
630×630	5	9	18	891
1000×630	6	12	24	1132
1000×1000	8	15	30	1414
1600×1000	10	19	38	1887
2000×1000	12	23	46	2236
2500×1600	15	30	60	2968



Sampling for Flatness Error



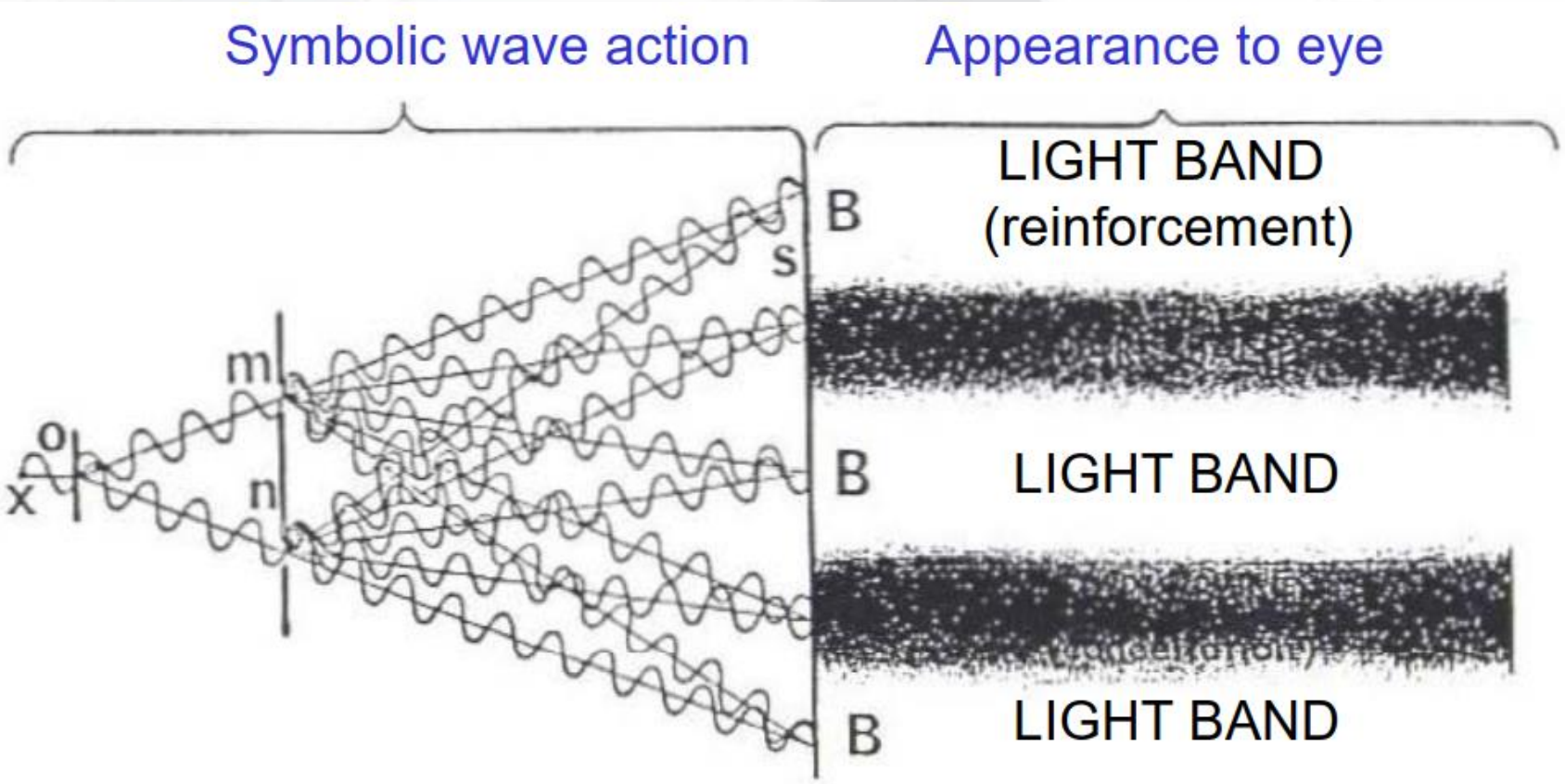
(a)方格型分割法

(Rectangular grid)

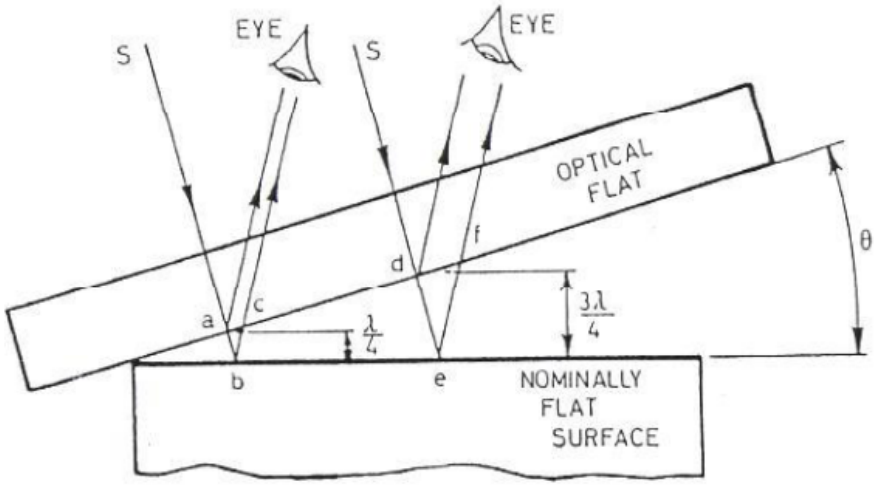
(b)米字型分割法

(Union jack)

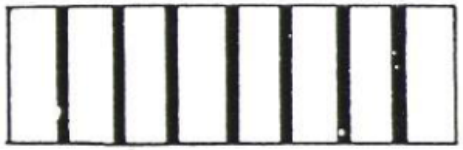
Fringe Formation



Optical Flat Used for Flatness Measurement

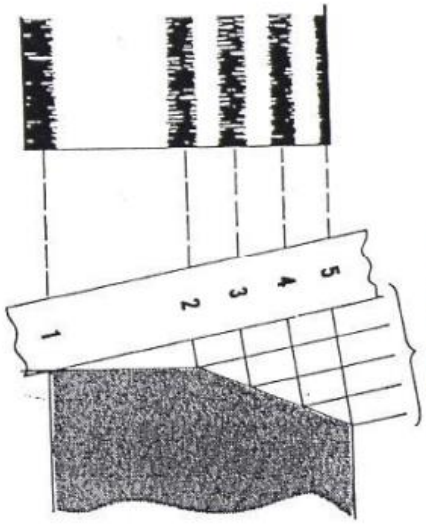


Formation of interference fringes on a flat surface viewed under an optical flat in a parallel beam of monochromatic light.



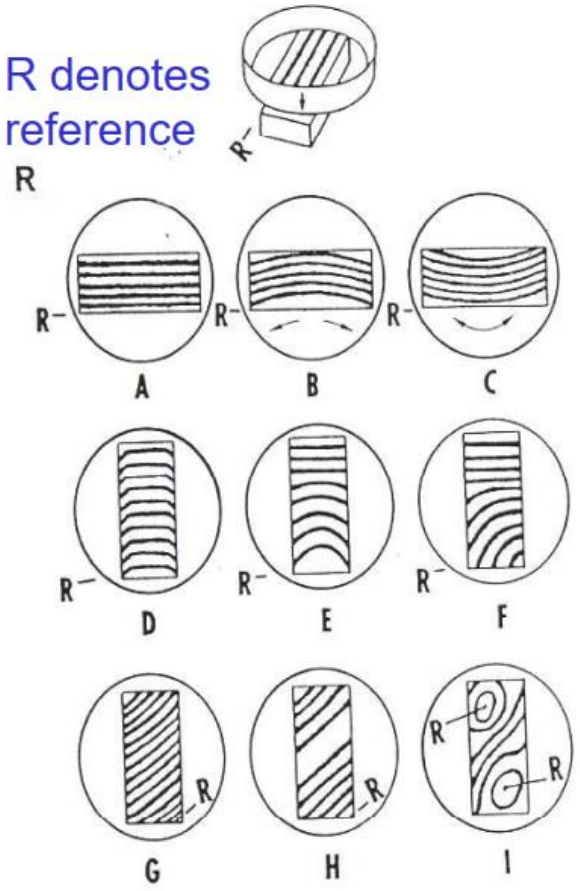
Interference fringes on a flat surface viewed under an optical flat in a parallel beam of monochromatic light .

Fringe Patterns



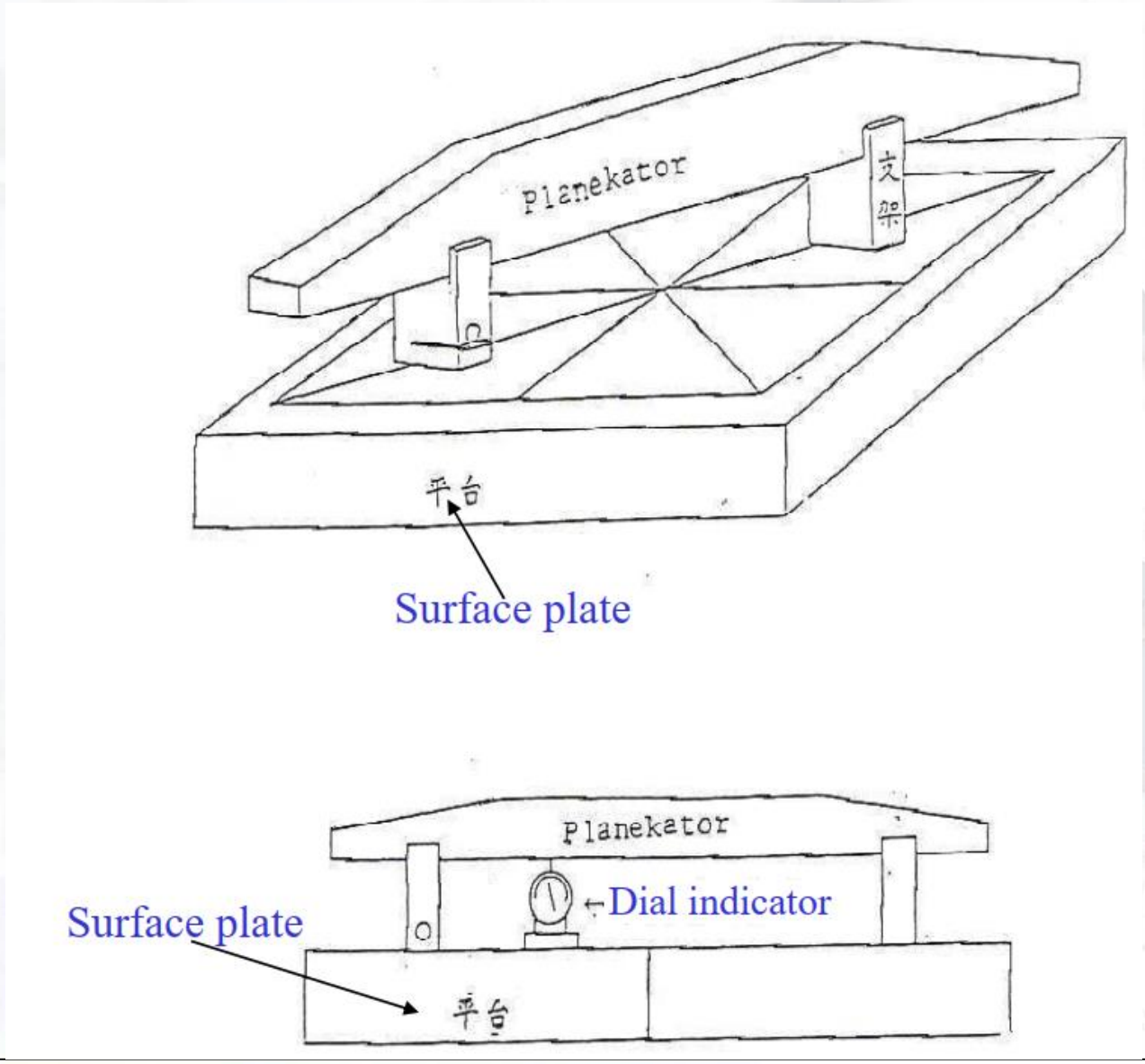
Parallel Separation Planes

The sharp drop-off is clearly shown by the close bands on the right.

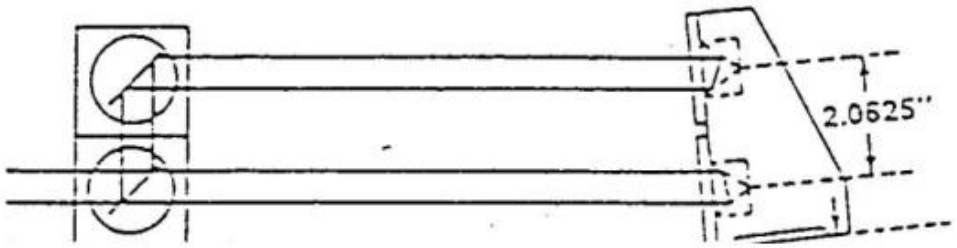


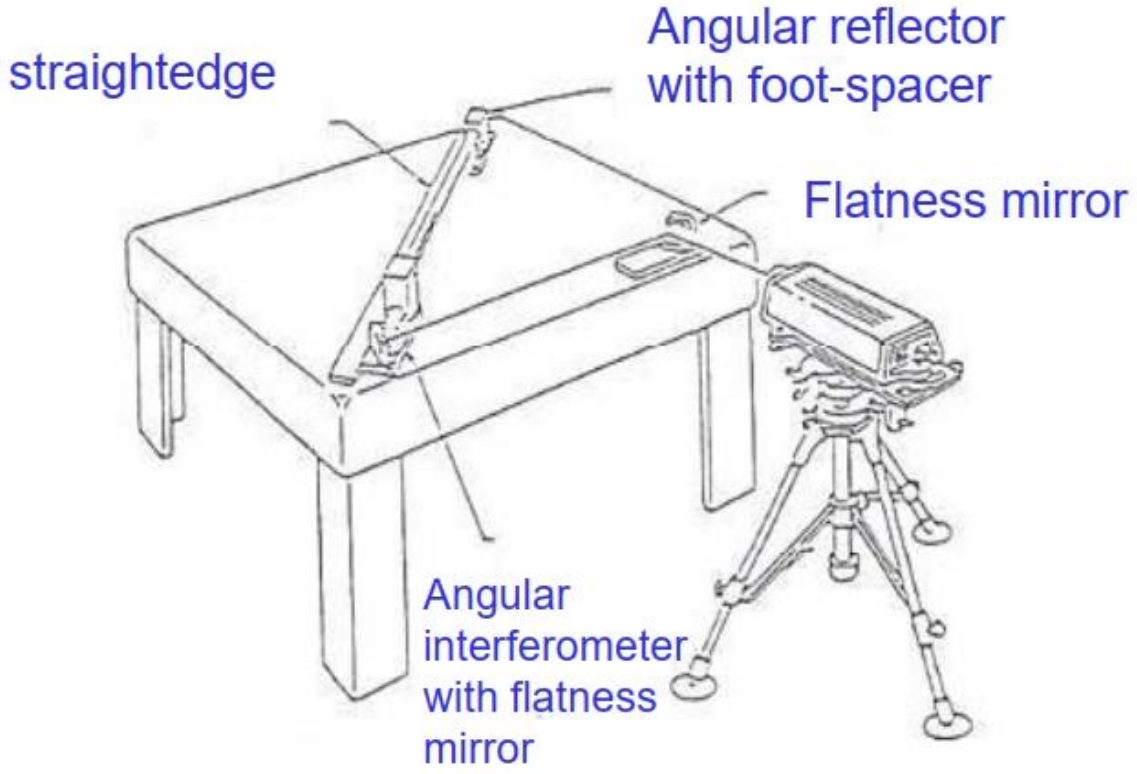
Fringe patterns reveal surface condition like contour lines on a map

Flatness Measurement Using Straight Edge

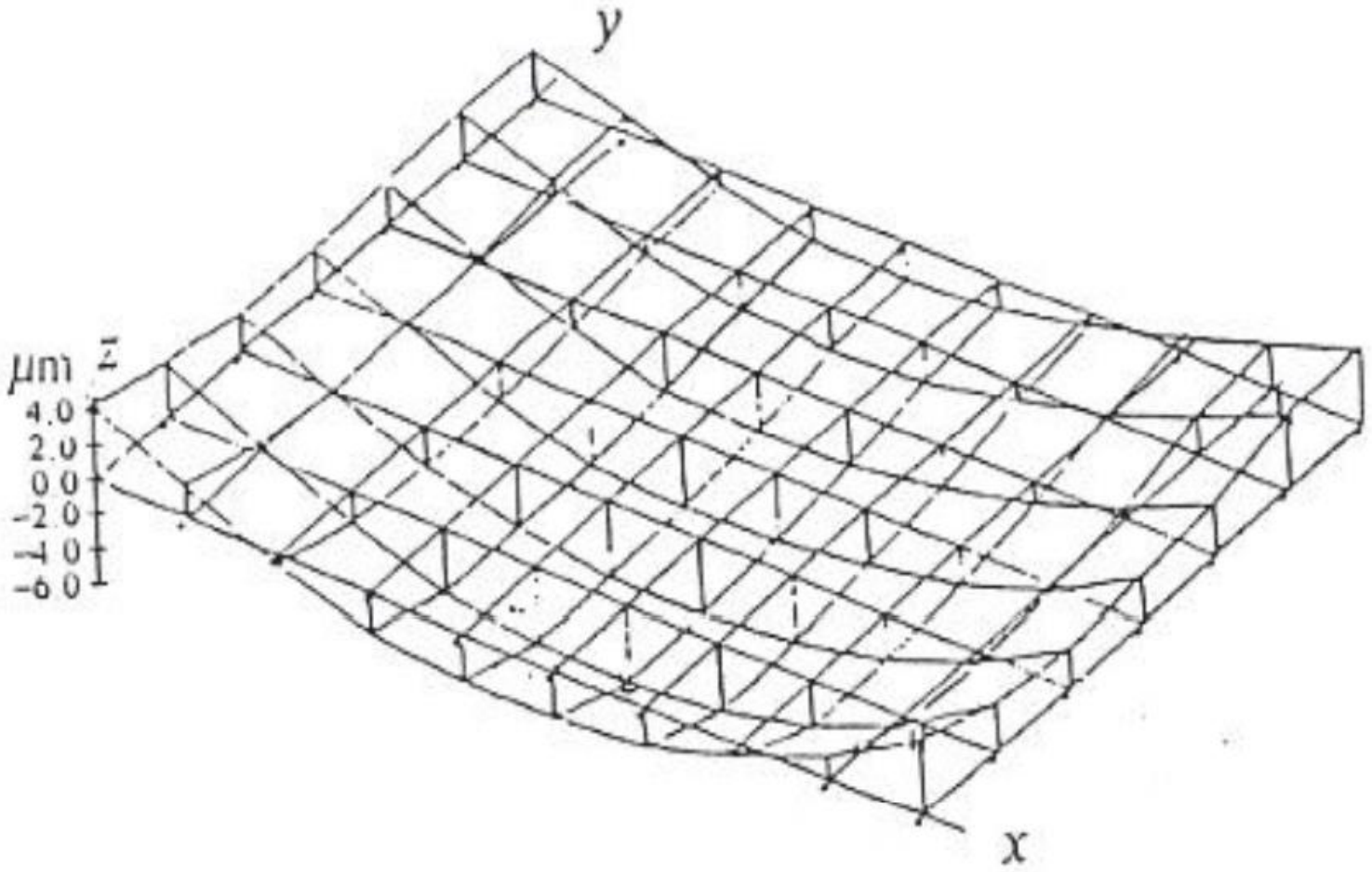


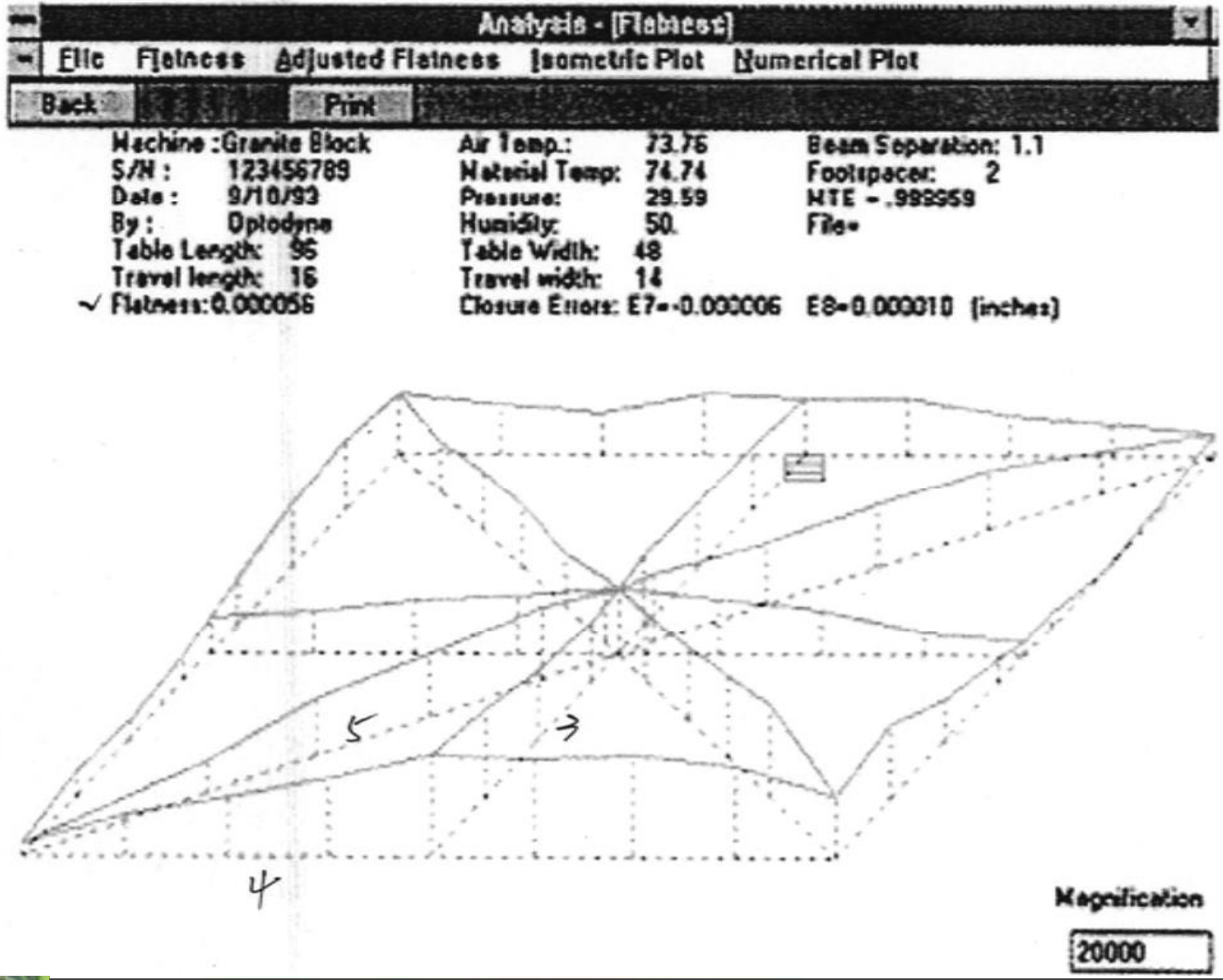
Interferometer Setup for Flatness Measurement



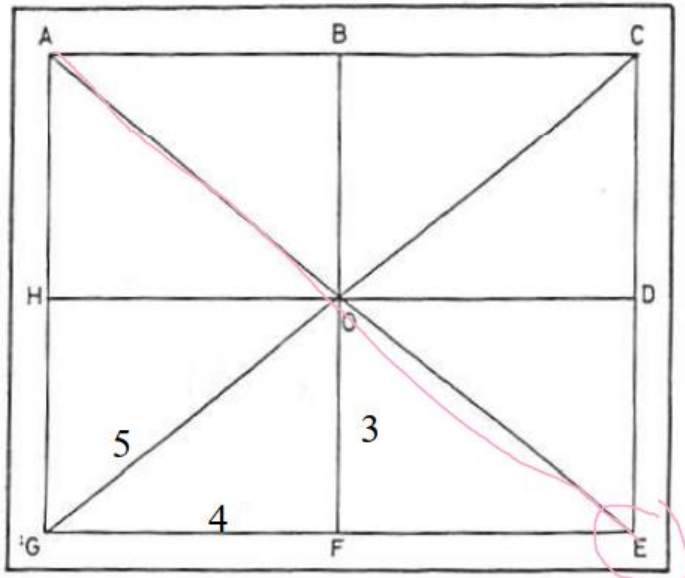


Flatness Error Using LSQ Method



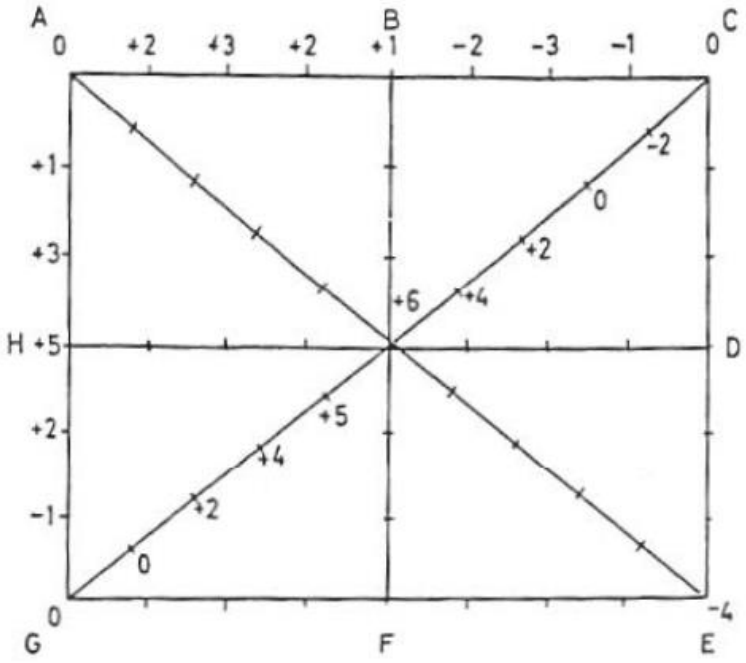

Analysis - [Flatness]
File Flatness Adjusted Flatness Isometric Plot Numerical Plot
Back Print
Machine :Granite Block
S/N : 123456789
Date : 9/10/93
By : Optodyne
Table Length: 96
Travel length: 16
Flatness:0.000056
Air Temp.: 73.76
Material Temp: 74.74
Pressure: 29.59
Humidity: 50.
Table Width: 48
Travel width: 14
Closure Errors: E7=-0.000006 E8=0.000010 (inches)
Beam Separation: 1.1
Footspacer: 2
Magnification
20000

Flatness Error Using Graphical Method



Lines of Test							
A–C	A–E	A–G	C-C	G–E	C–E	B–F	H–D
0	0	0	0	0	0	0	0
0	0	0	0	0	0	−9	0
−1	0	+1	+2	+1	−1	+1	+3
−4	−1	+2	+4	−3	+2	+2	+7
−7	−2	−2	+5	−6	+5	−2	+9
−12	−4	−6	+6	−8	+3	−5	+9
−15	−8	−6	+4	−9	+2		+6
−15	−12		+2	−11			+9
	−17		0	−12			+10
	−21		−2				
	−24		0				

Surface table marked out with the minimum number of lines for a flatness test



Cumulative Error	*Correction*	*Height Relative to Plane ACG*
0	0	0
0	+2	+2
0	+4	+4
−1	+6	+5
−2	+8	+6
−4	+10	+6
−8	+12	+4
−12	+14	+2
−17	+16	−1
−21	+18	−3
−24	+20	−4

Three corners of a surface adjusted to zero enable the height of the mid-point to be fixed relative to a plane through the corners. this enables the Height of the other corner to be determined.

Correction for Line C E

Cumulative Error	Correction Rel. to ACG	Error Rel. to ACG
0	0	0
0	−1	−1
−1	−2	−3
+2	−3	−1
+5	−4	+1
+3	−5	−2
+2	−6	−4

Correction for Line G E

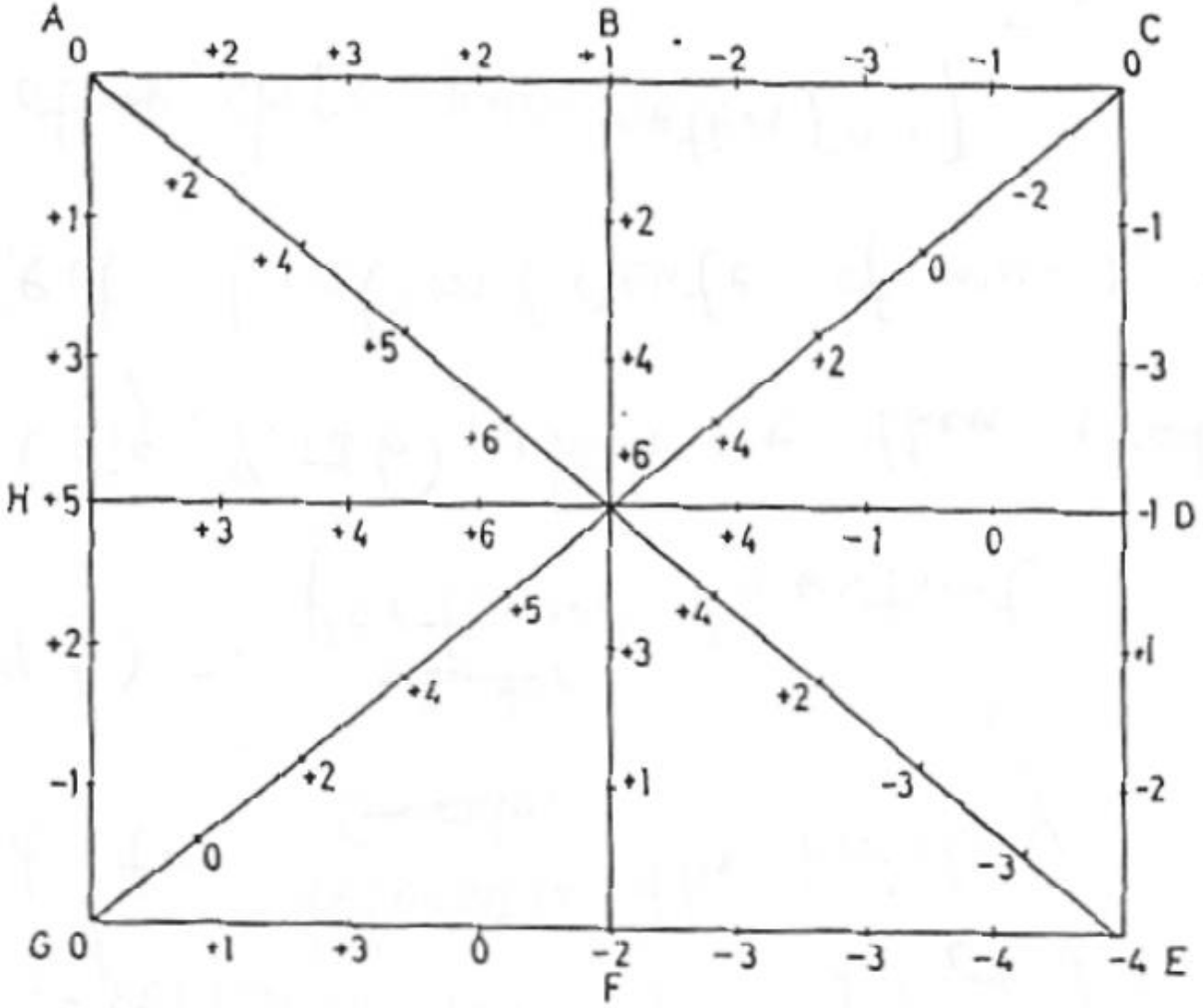
Cumulative Error	Correction Rel. to ACG	Error Rel. to ACG
0	0	0
0	+1	+1
+1	+2	+3
−3	+3	0
−6	+4	−2
−8	+5	−3
−9	+6	−3
−11	+7	−4
−12	+8	−4

Correction for Line B F

Cumulative Error	Initial Correction	Correction	Error Rel. to ACG
0	+1	0	+1
0	+1	+1	+2
+1	+2	+2	+4
+2	+3	+3	+6
−2	−1	+4	+3
−5	−4	+5	+1
−9	−8	+6	−2

Correction for Line H D

Cumulative Error	Initial Correction	Correction	Error Rel. to ACG
0	+5	0	+5
0	+5	−2	+3
+3	+8	−4	+4
+7	+12	−6	+6
+9	+14	−8	+6
+9	+14	−10	+4
+6	+11	−12	−1
+9	+14	−14	0
+10	+15	−16	−1



Height of all measured points related to an arbitrary plane ACG

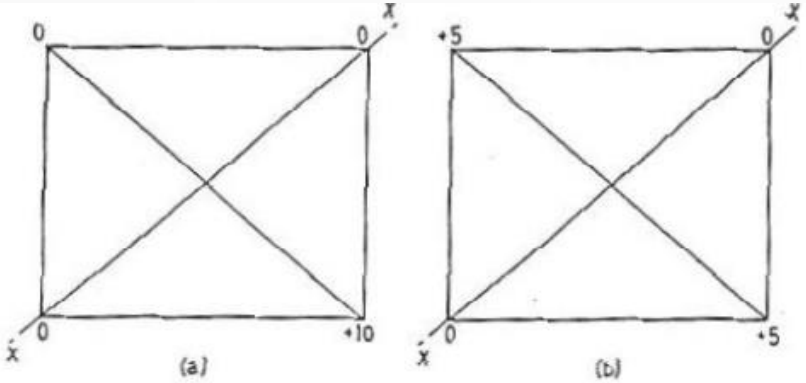
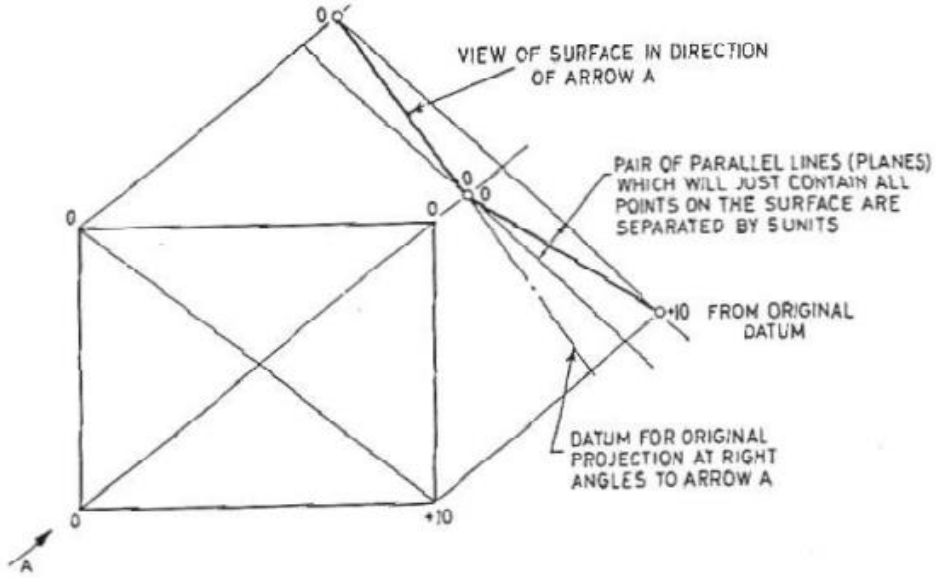


Fig12.5(a) Initial assessment shows a flatness error of +10 units at one corner relative to an arbitrary plane
(b) By tilting the whole surface about axis XX , the actual Error is shown to be +5 units



The true flatness error of +5units.obtained by titling in fig12.5(b)can also be obtained by projection

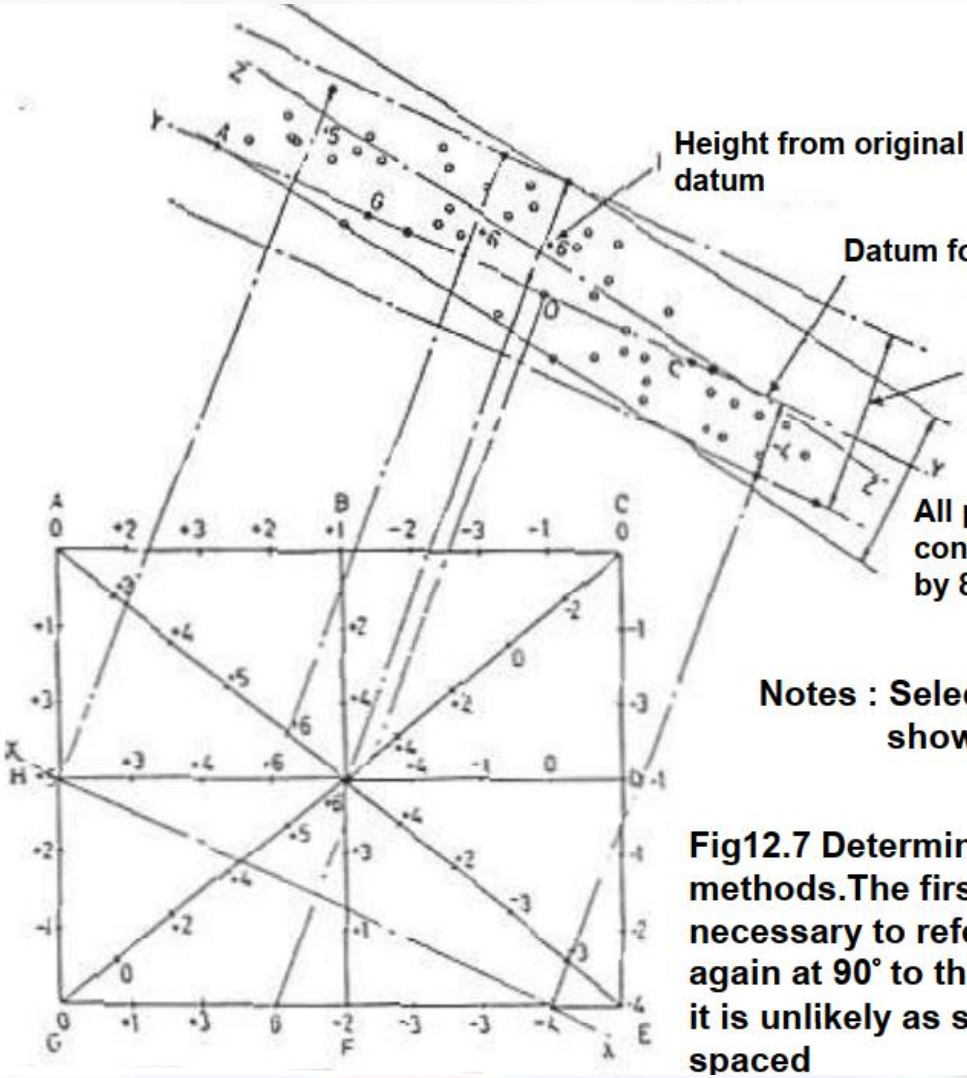


Fig12.7 Determination of flatness error by graphical methods.The first projection only is shown.It may be necessary to refer all points to line ZZ and project again at 90° to the original projection , but in this case it is unlikely as some of the new maxima are widely spaced

Journal Review

A new minimum zone method for evaluating flatness errors

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A new minimum zone method for flatness error analysis is proposed in this article. Based on the criteria for the minimum zone solution and strict rules for data exchange, a simple and rapid algorithm, called the control plane rotation scheme, is developed for the flatness analysis of a flat surface. Experimental work was performed, and some examples are given in terms of the minimum zone and least-squares solutions.

Keywords: *flatness; minimum zone method; least-squares method*

THANK YOU
FOR YOUR ATTENTION!