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THE NUCLEATION AND GROWTH OF SOME EUTECTICS

Volume II

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VOLUME II

FIGURES, PLATES and TABLES

For easy reference, the page numbers have been made to correspond with the figure, plate and table numbers.

Where necessary the Growth Direction has been indicated by an arrow and the initials G.D. On longitudinal sections of unidirectionally grown specimens the growth direction is from left to right unless indicated otherwise.

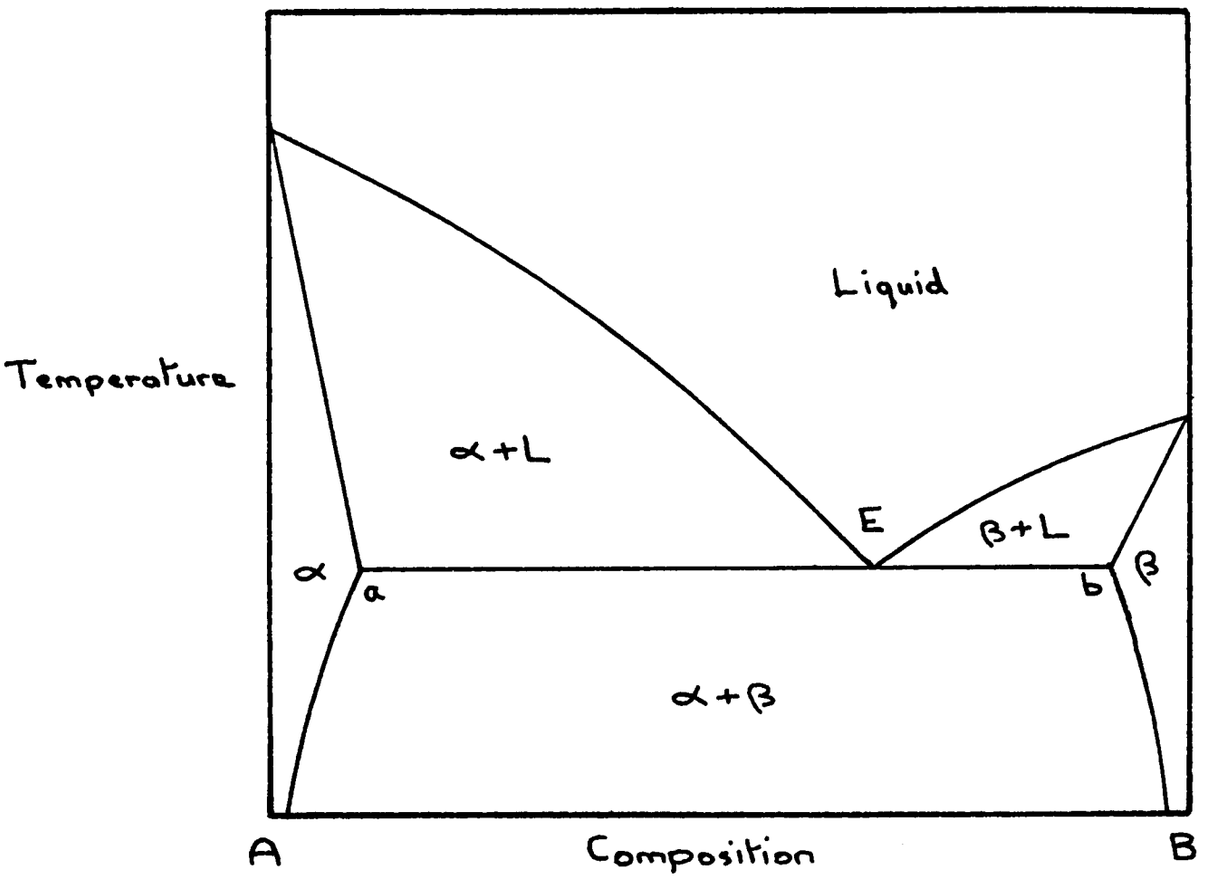


FIG.1 Binary Eutectic Phase Diagram

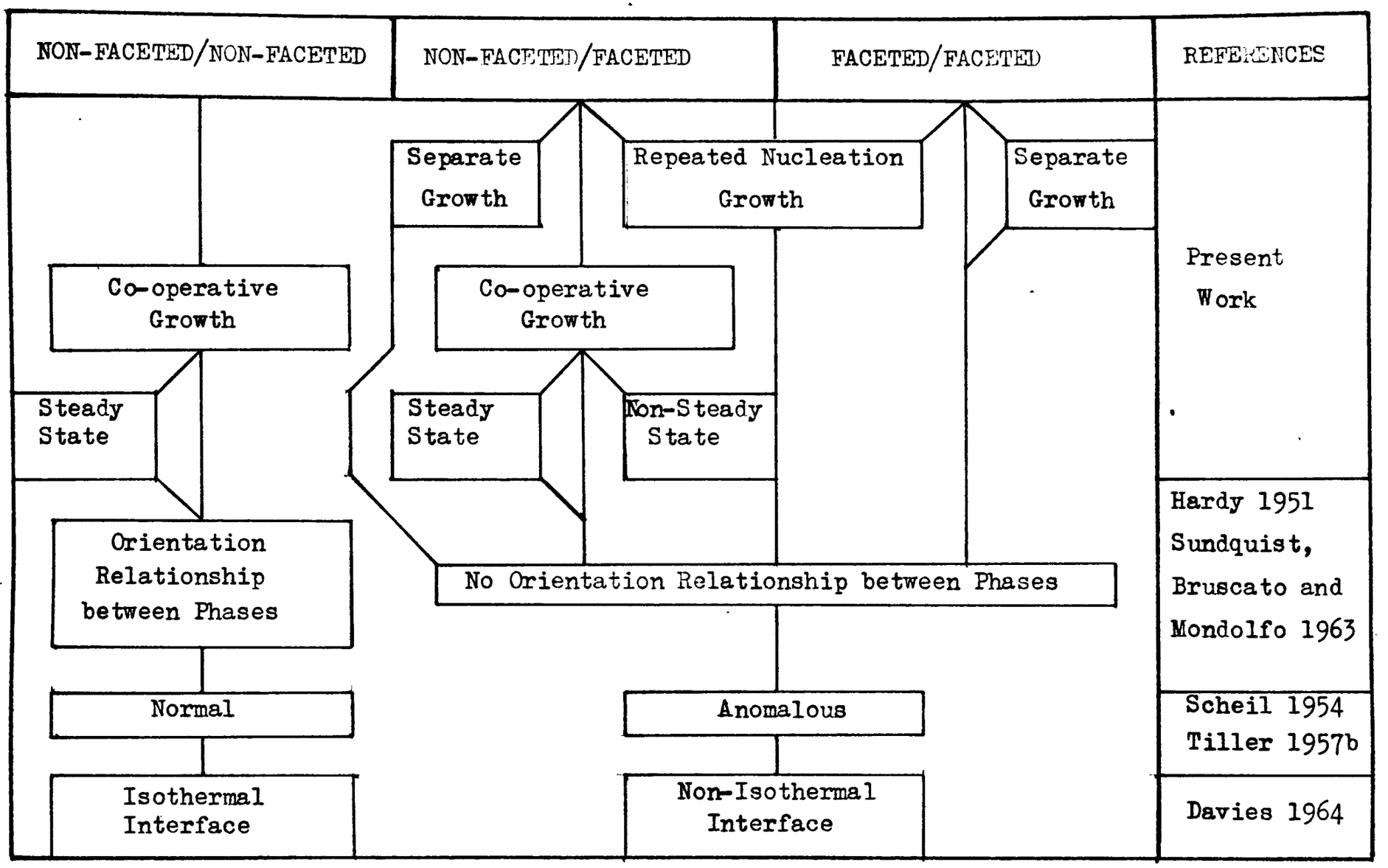


FIG. 2. Eutectic Classification Diagram

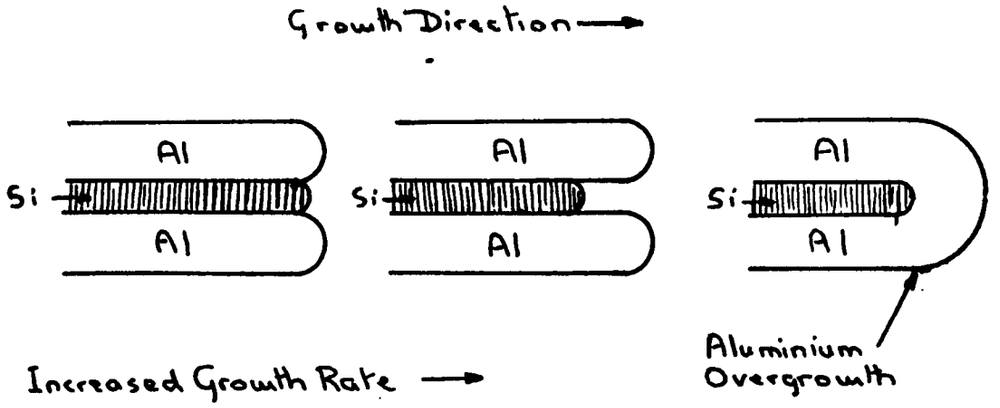


FIG. 3a Thall and Chalmers' Al/Si Eutectic Growth Model

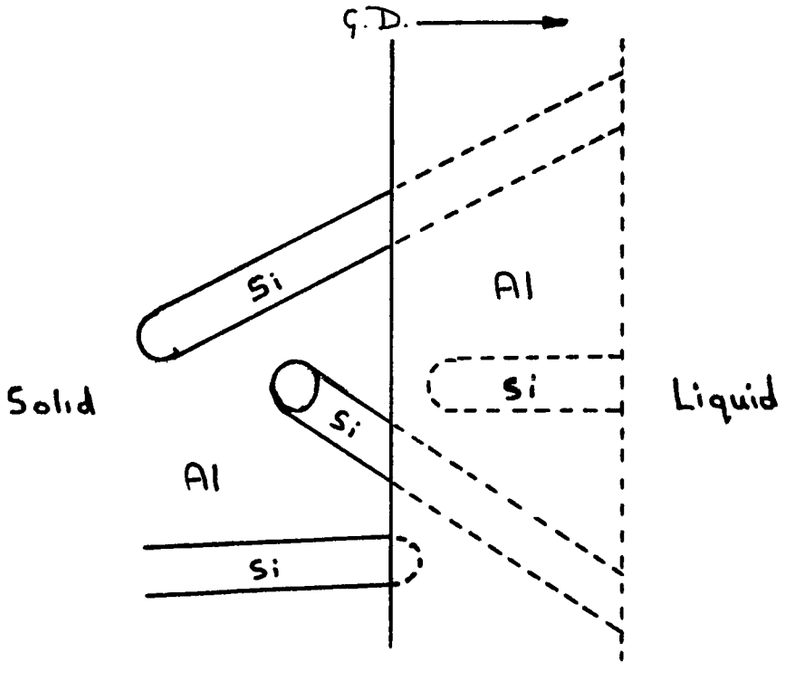


FIG. 3b Chadwick's Al/Si Eutectic Growth Model

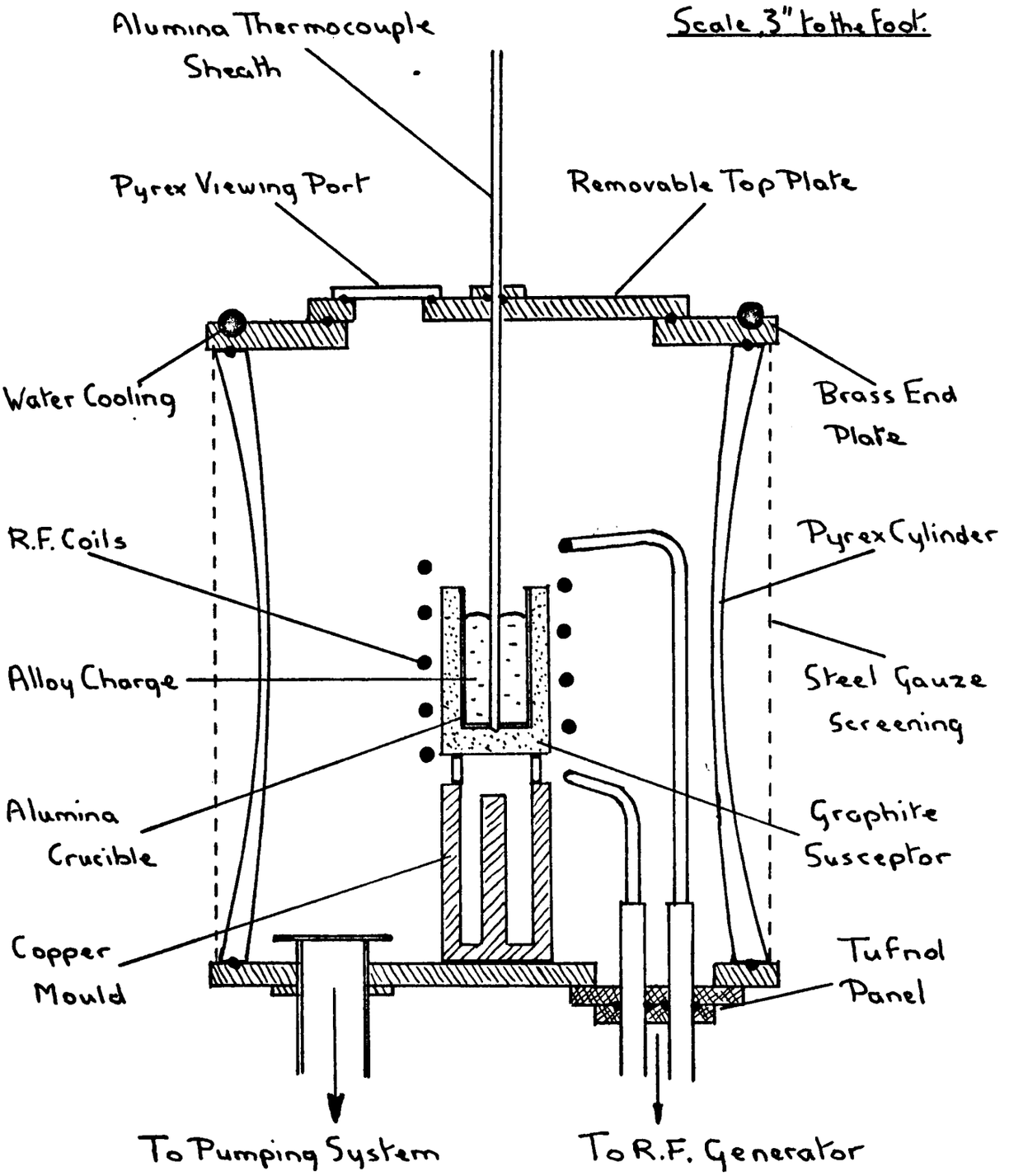
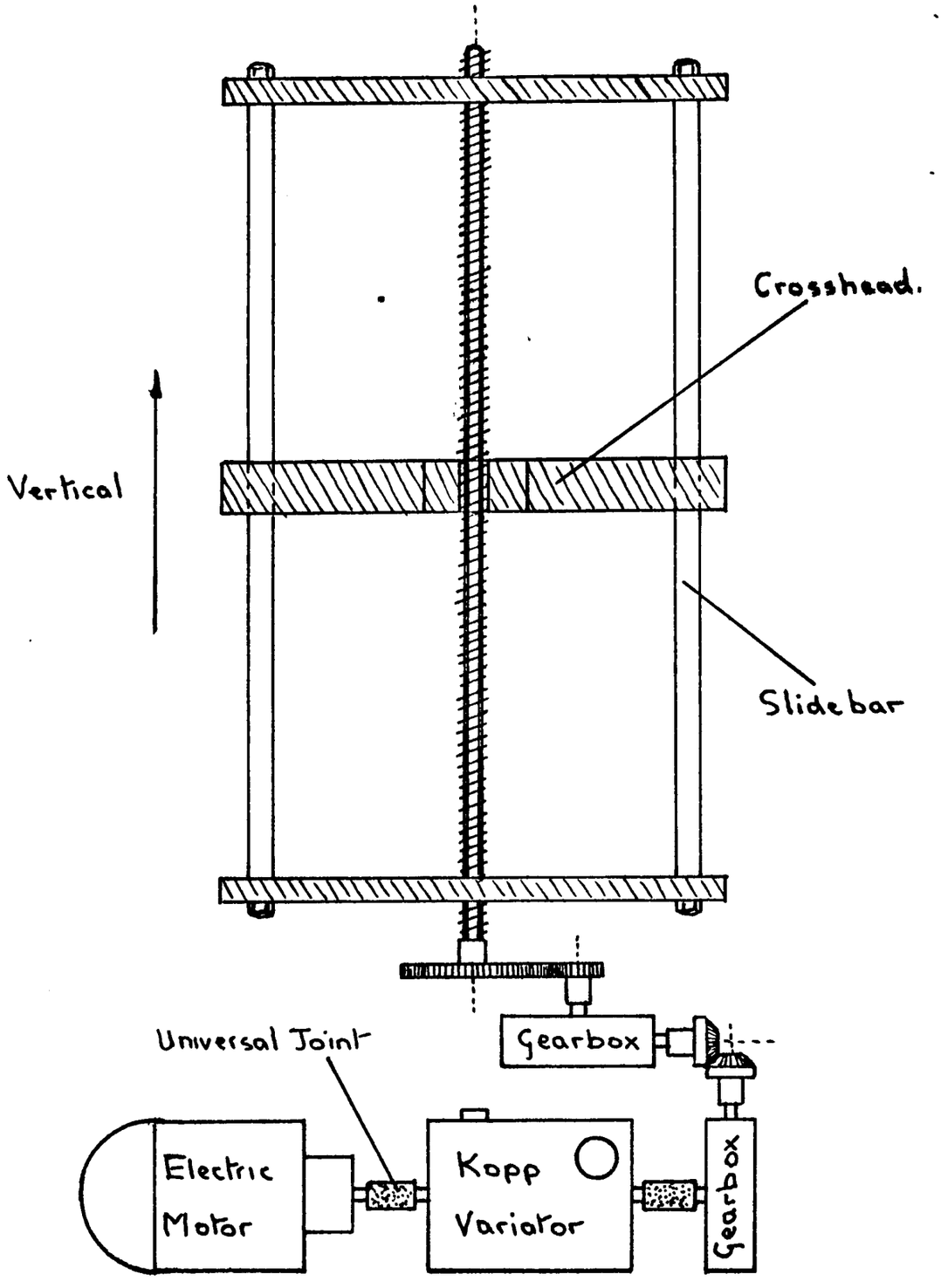


FIG. 4 Bell Jar Furnace

(as for vacuum melting and casting)



Scale. 3" to one foot

FIG. 5 Mechanical Pulling Device

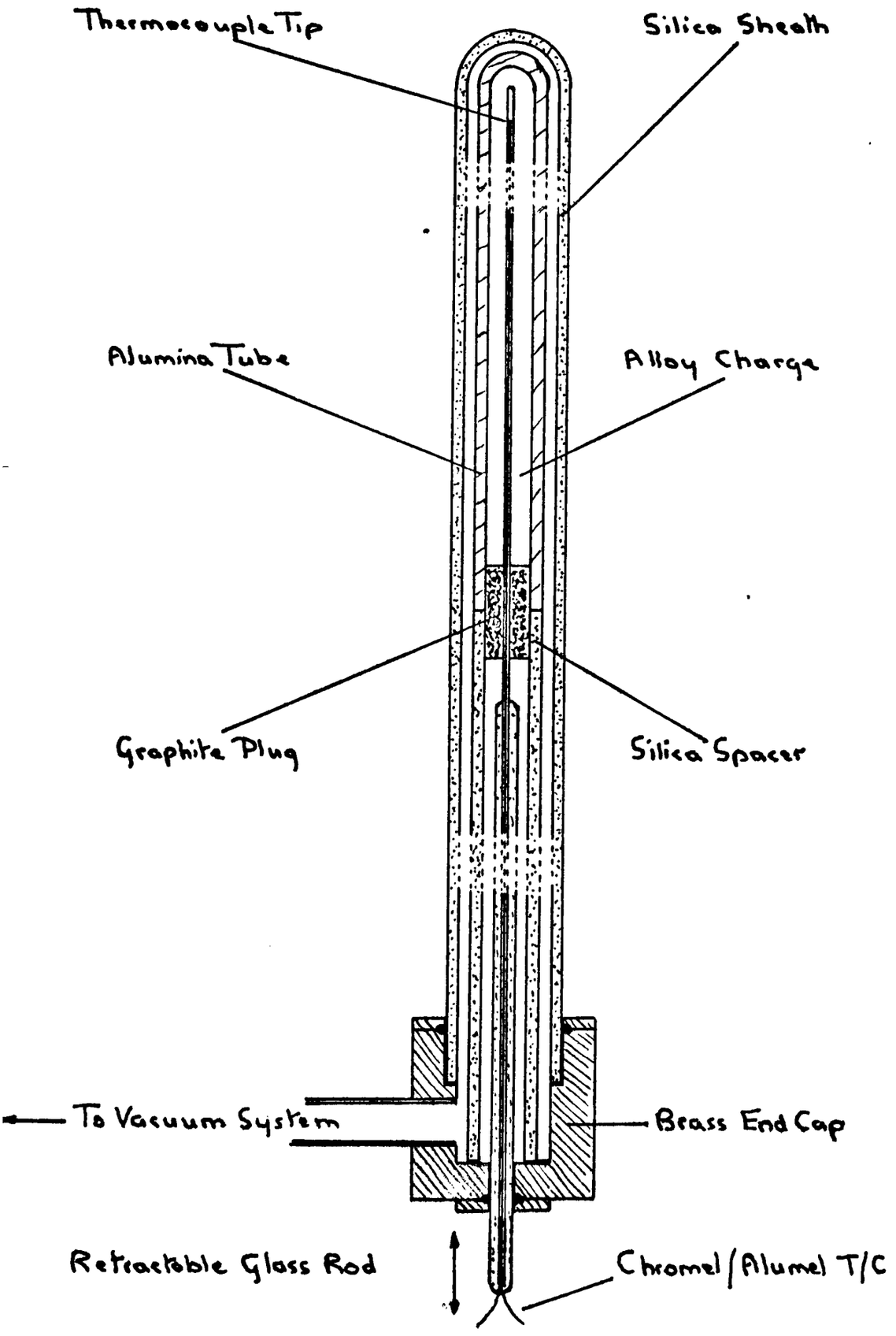


FIG. 6 Temperature Gradient Measuring Device

(full scale - total length of apparatus = 2')

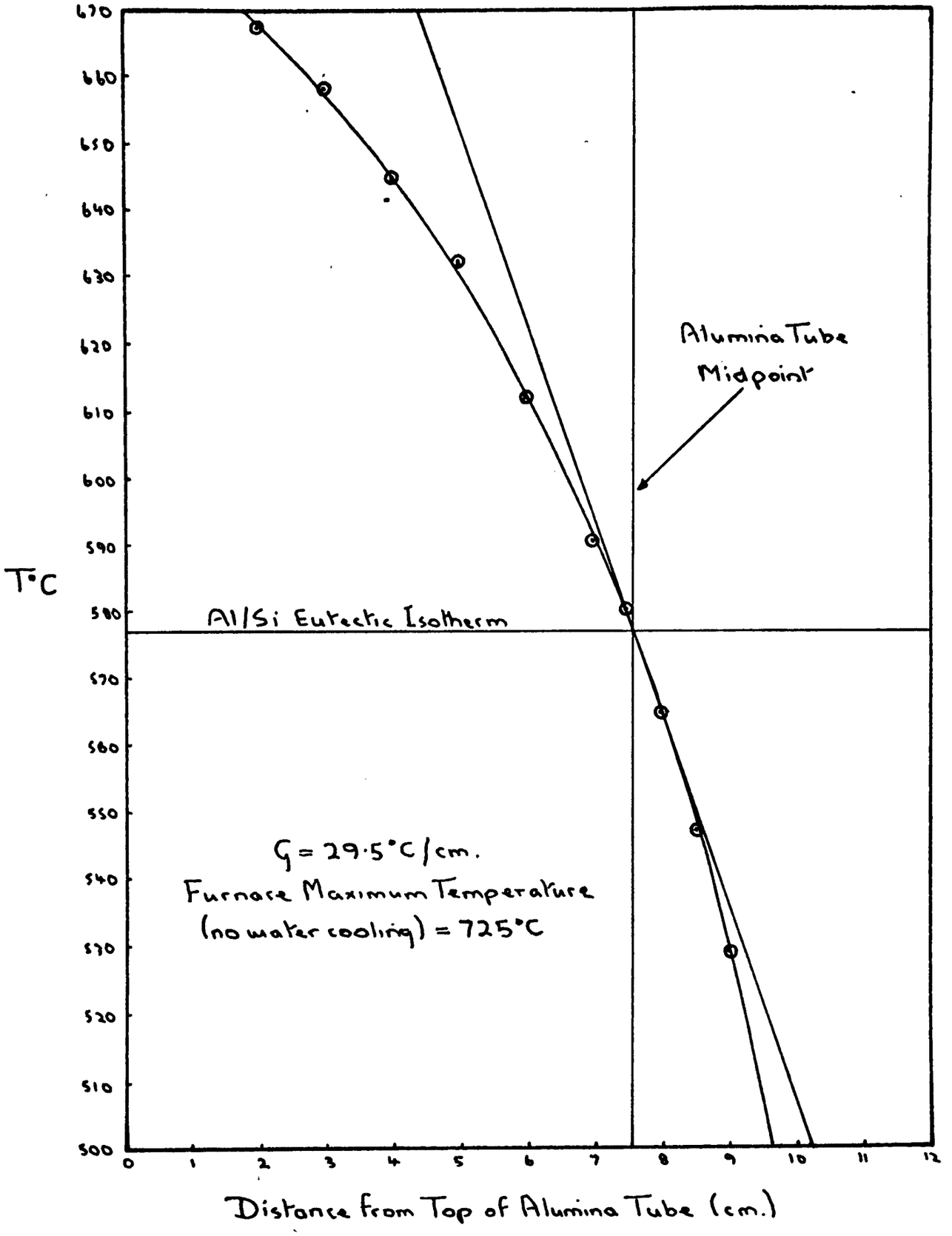


FIG. 7 A Specimen Temperature Gradient Graph

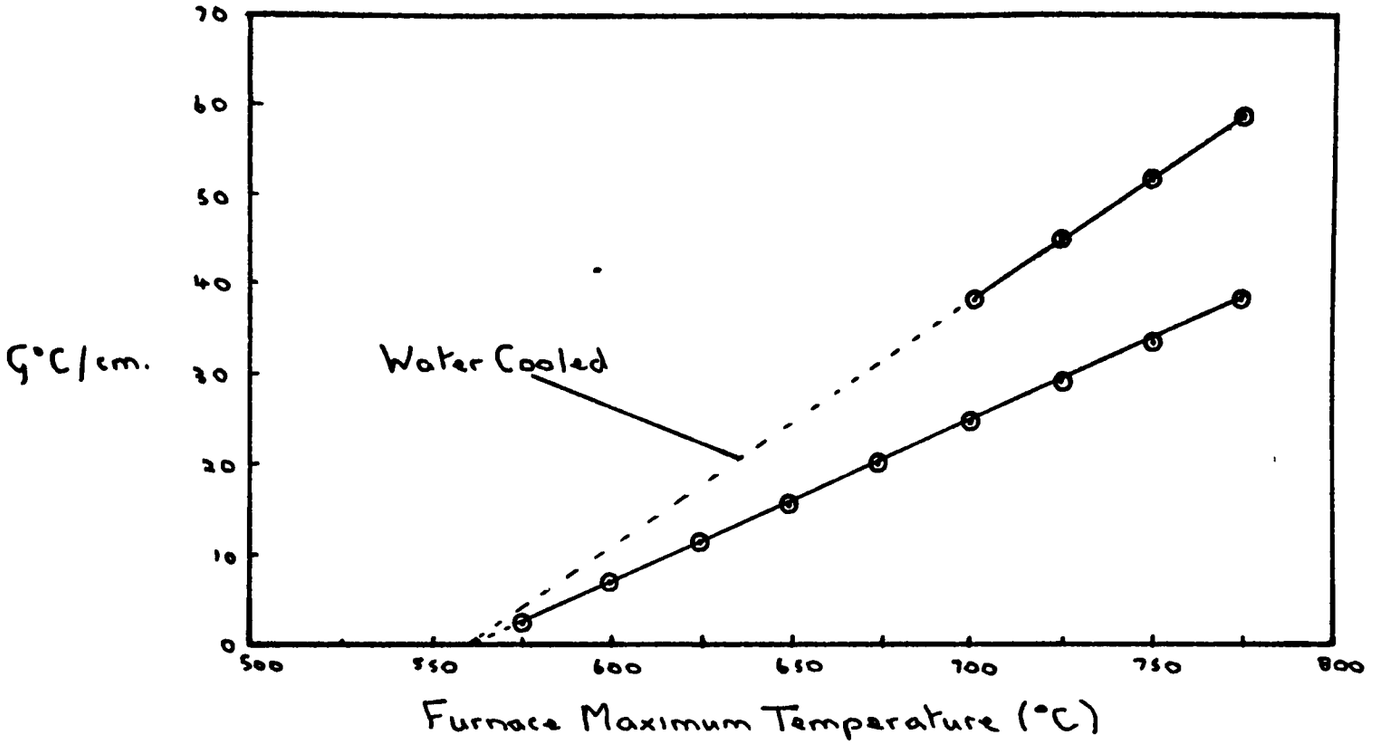


FIG. 8a Temperature Gradient Calibration Curves (Nichrome furnace)

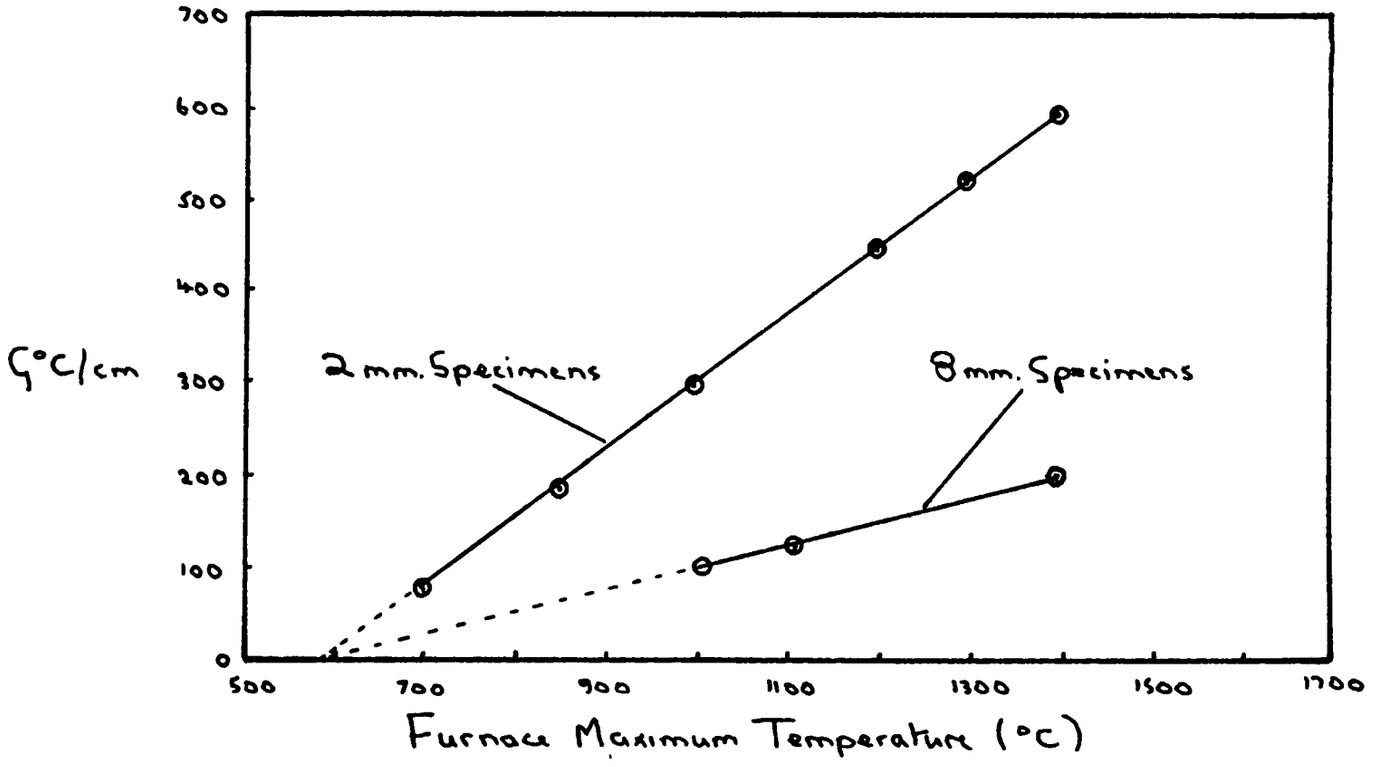


FIG. 8b Temperature Gradient Calibration Curves (Platinum furnace)

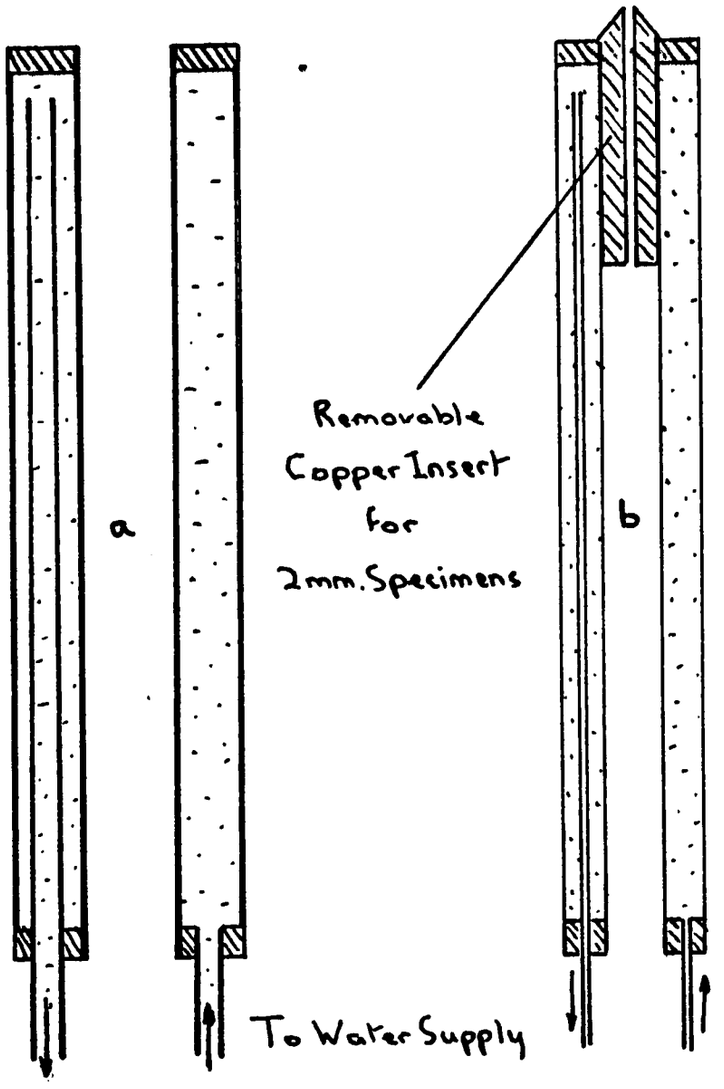


FIG. 9

a. Water Cooling Insert for Nichrome Furnace (half scale)

b. Water Cooling Insert for Platinum Furnace (half scale)

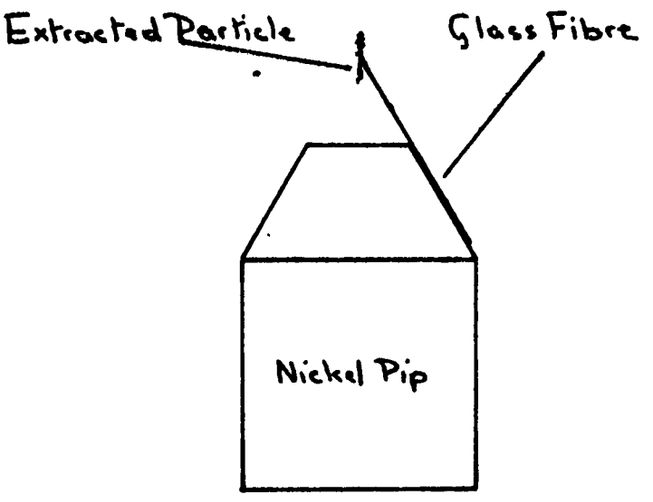


FIG. 10a Unicam Specimen Pip with Extracted Particle (x 5)

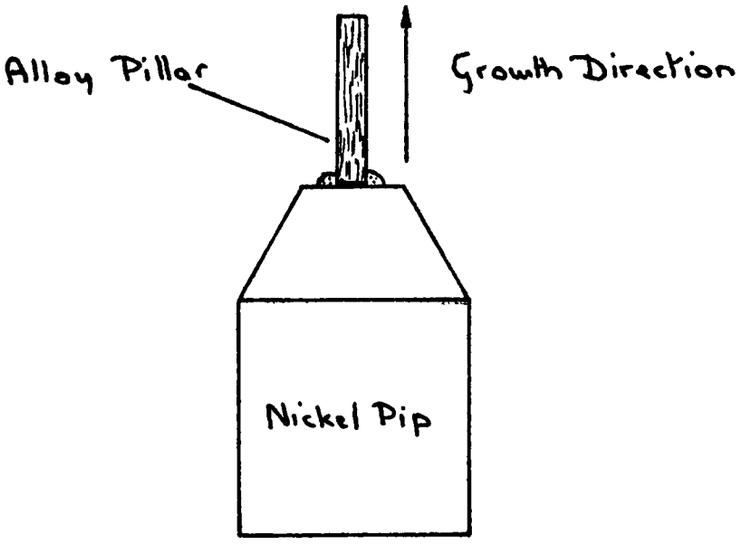


FIG. 10b Unicam Specimen Pip with Small Pillar of Eutectic (x 5)

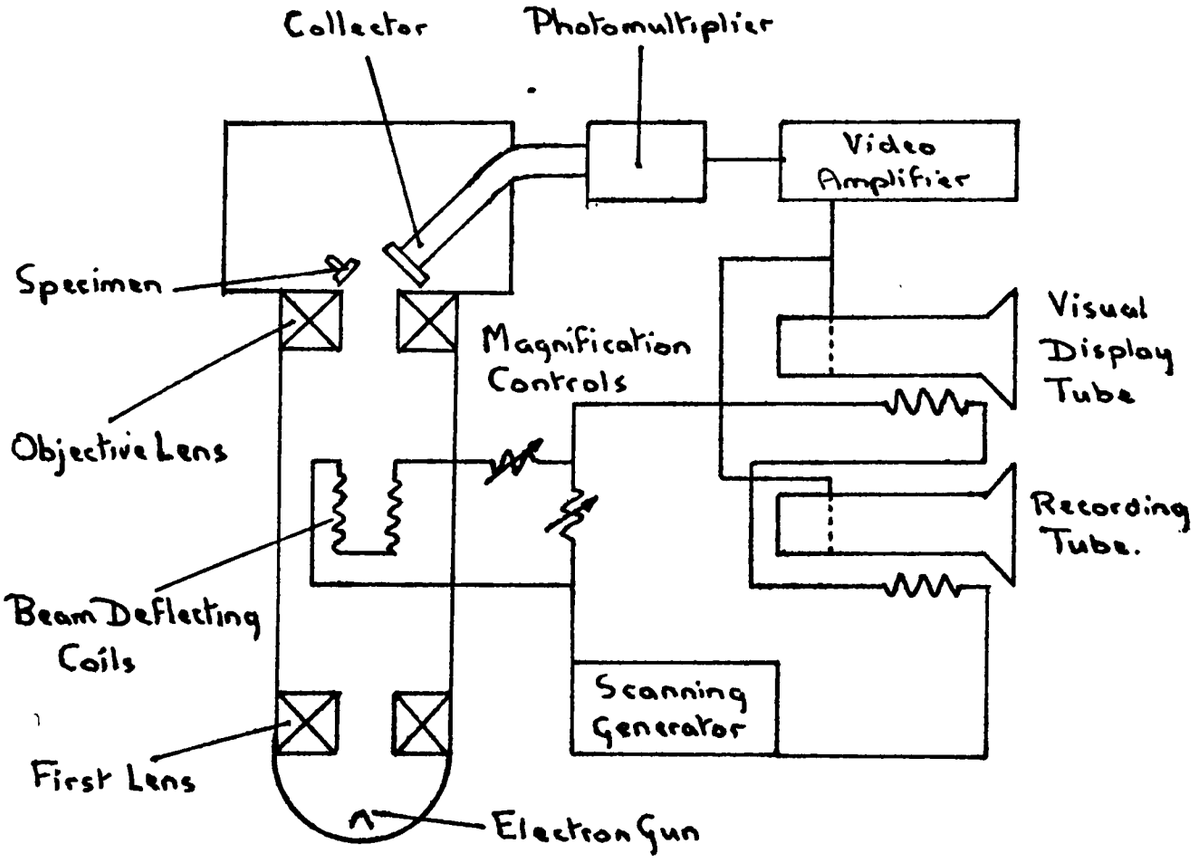


FIG. 11 Block Diagram of Scanning Electron Microscope

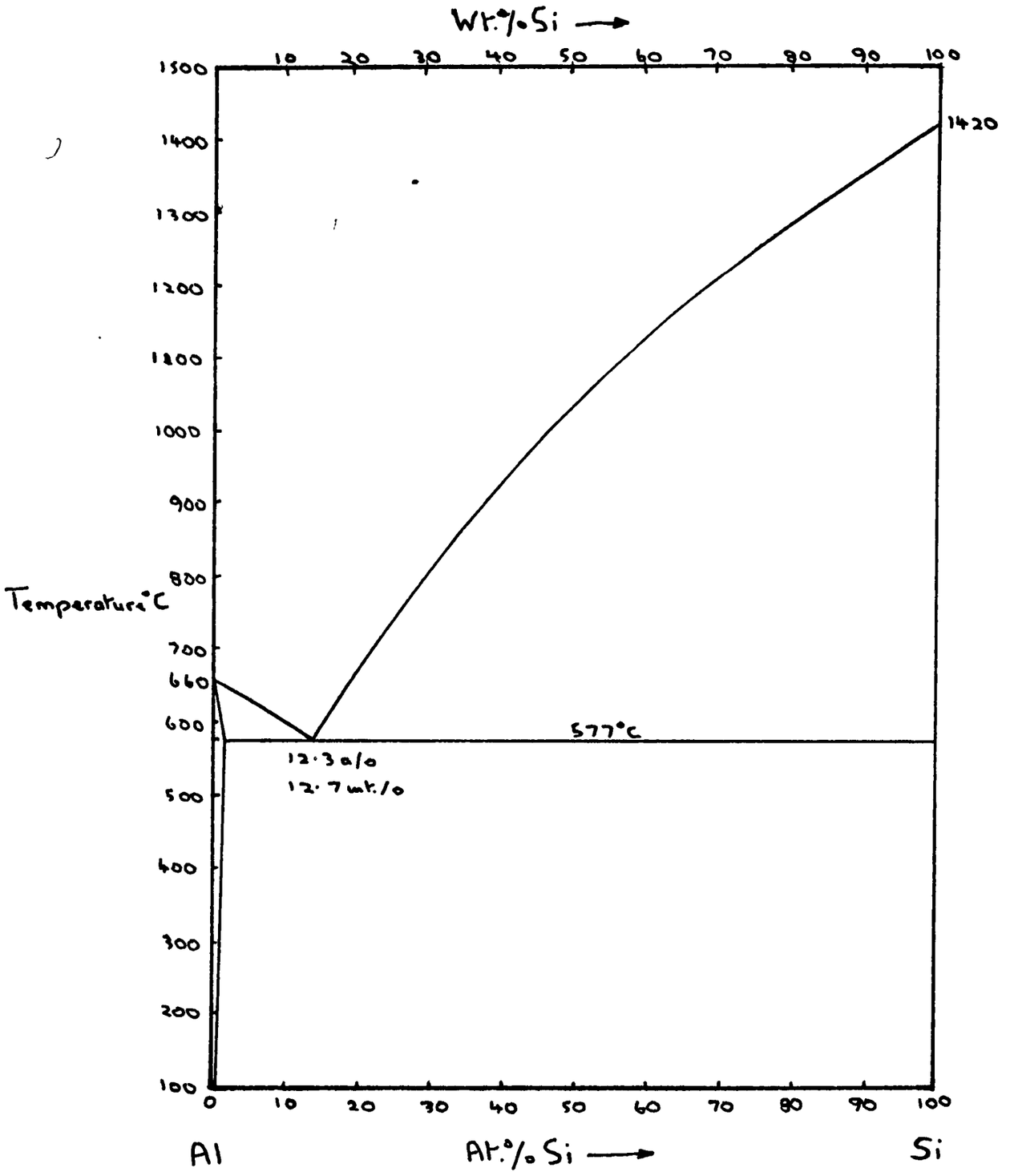


FIG. 12 Aluminium/Silicon Phase Diagram
(volume fraction of eutectic silicon = 0.13)

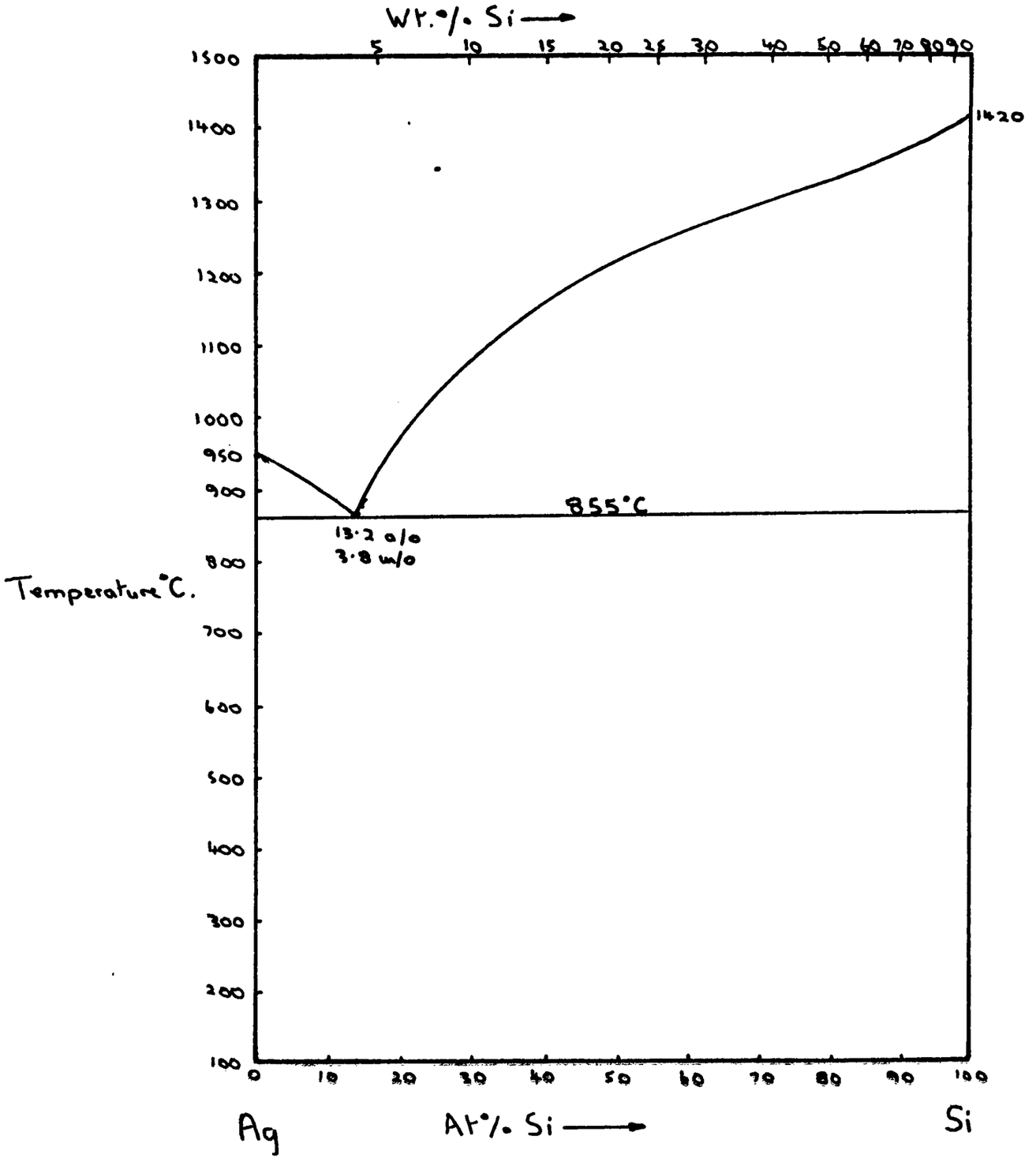


FIG. 13 Silver/silicon Phase Diagram
(volume fraction of eutectic silicon = 0.17)

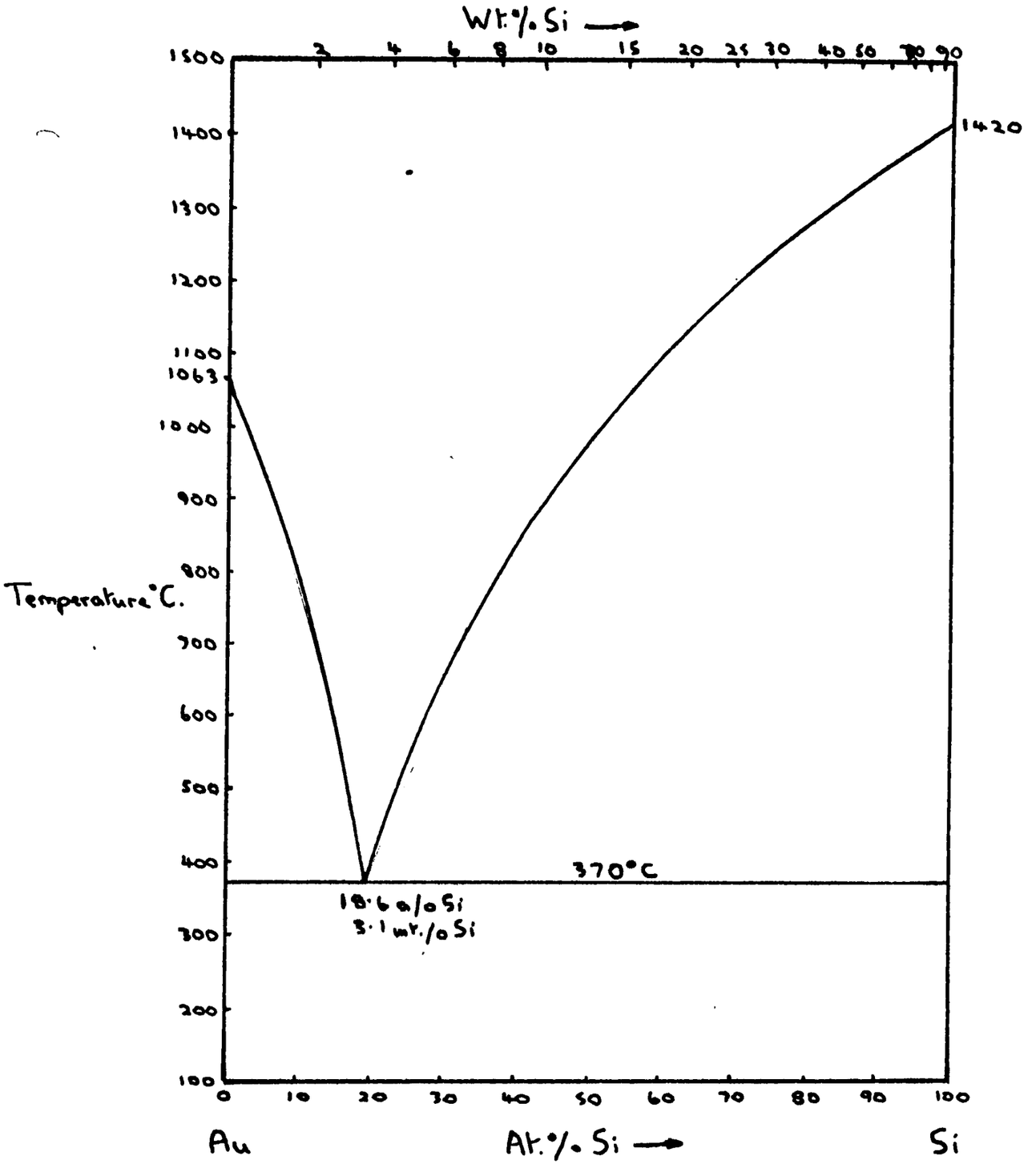
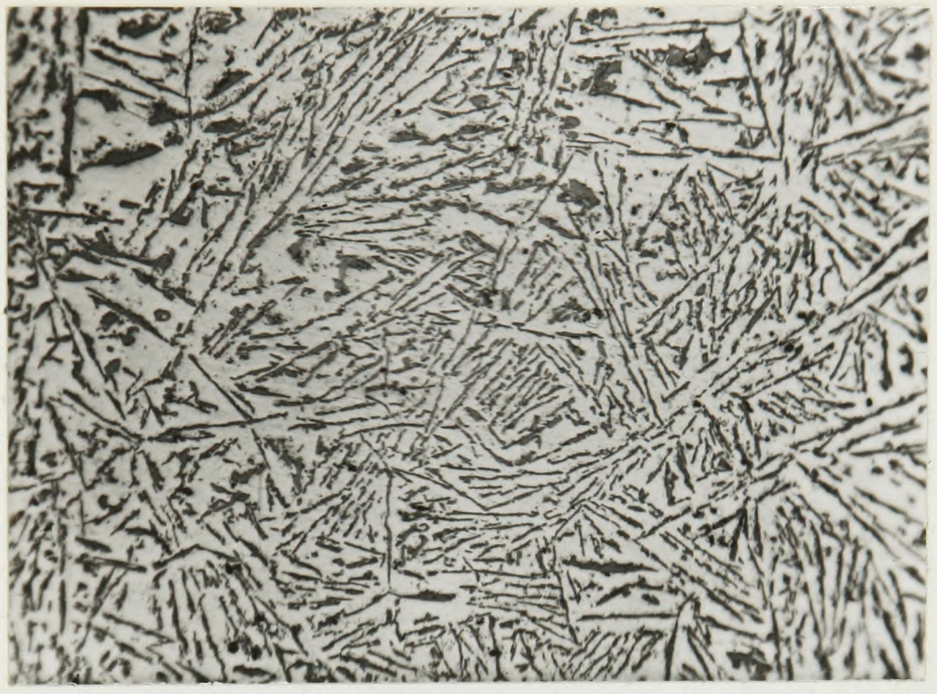
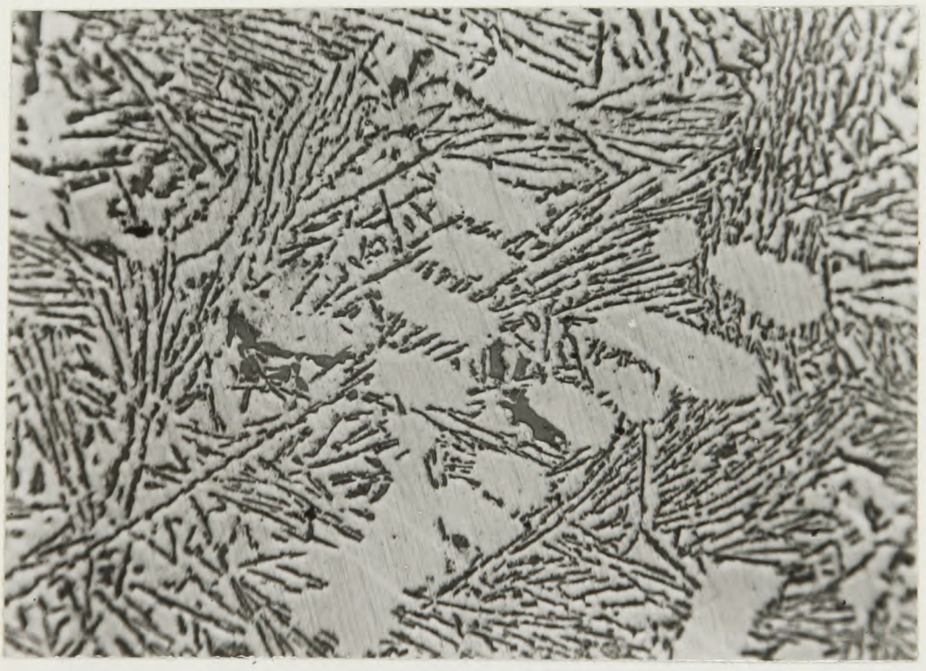


FIG. 14 Gold/Silicon Phase Diagram
(volume fraction of eutectic silicon = 0.26)



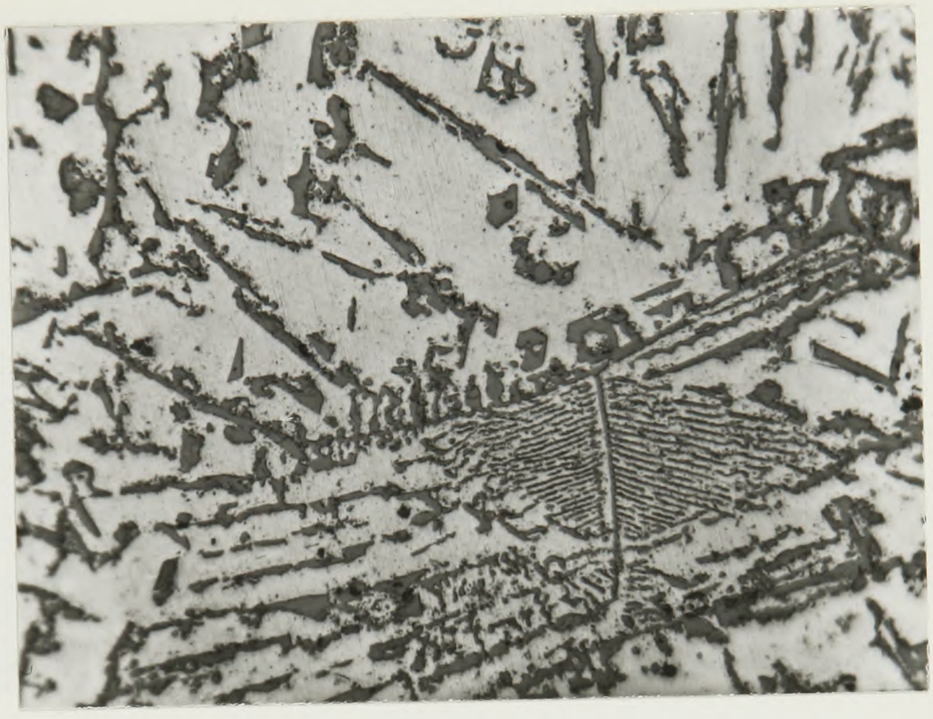
x 225

PLATE 15a Furnace-cooled Al/Si Eutectic



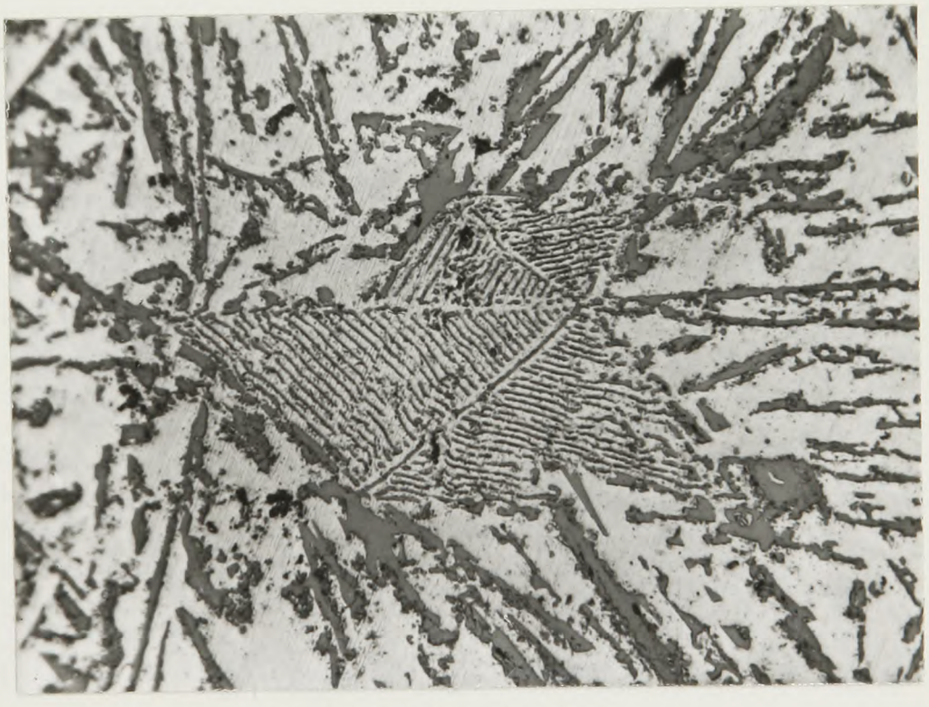
x 225

PLATE 15b Furnace-cooled Al/Si Eutectic



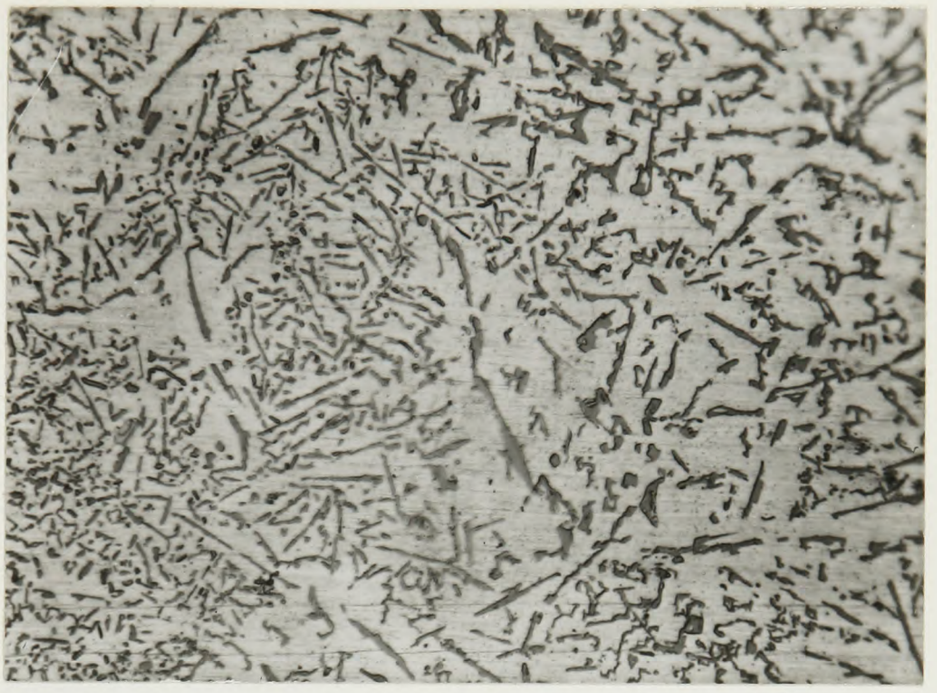
x 460

PLATE 16a Furnace-cooled Al/Si Eutectic



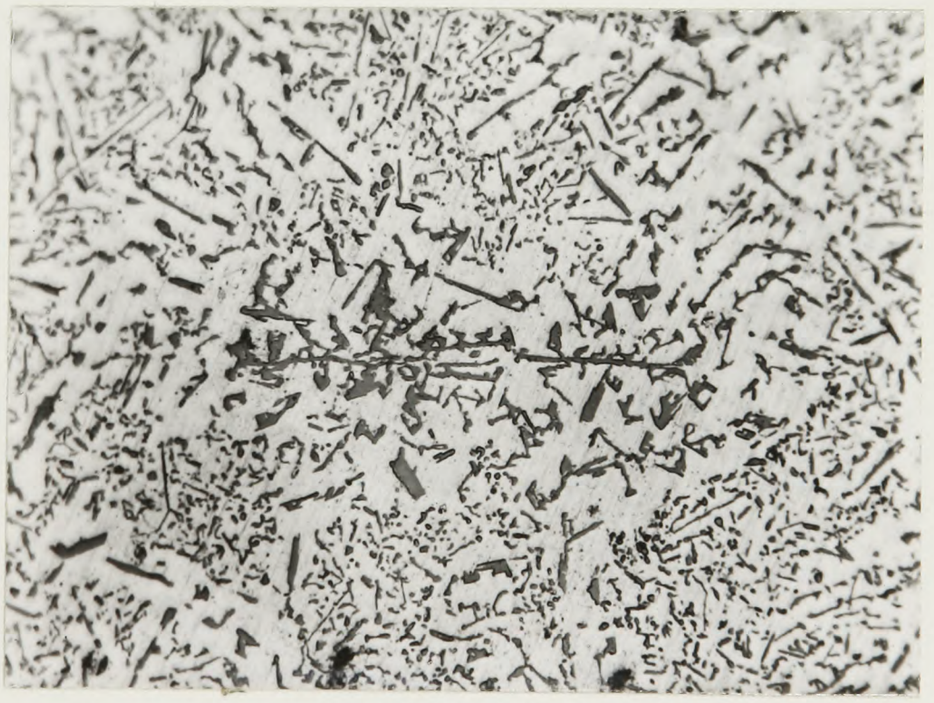
x 460

PLATE 16b Furnace-cooled Al/Si Eutectic



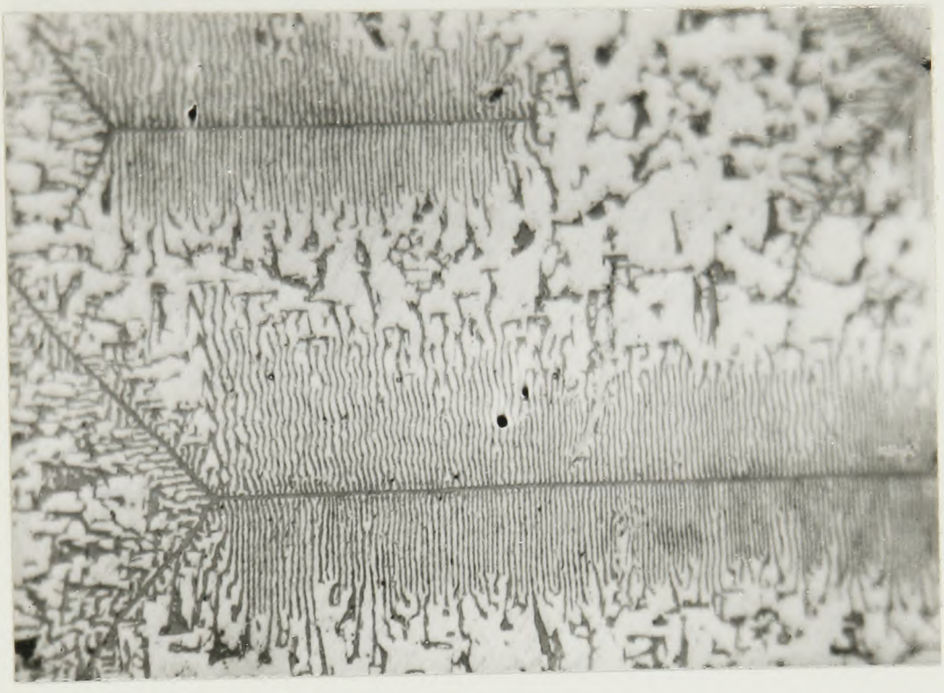
x 460

PLATE 17a Furnace-cooled Ag/Si Eutectic



x 460

PLATE 17b Furnace-cooled Ag/Si Eutectic

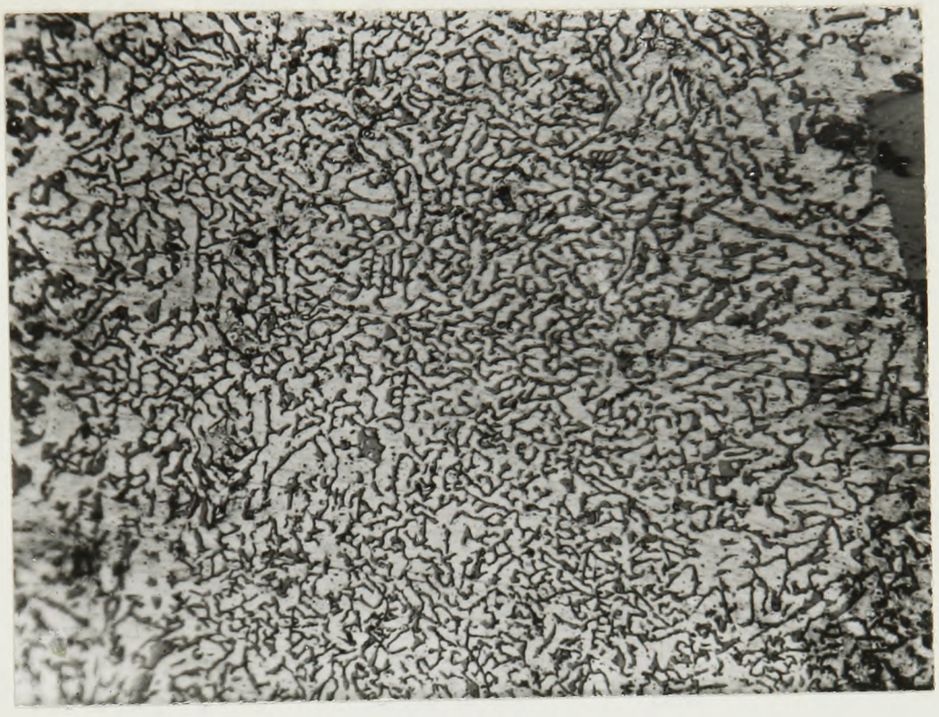


x 460

PLATE 18a Furnace-cooled Ag/Si Eutectic

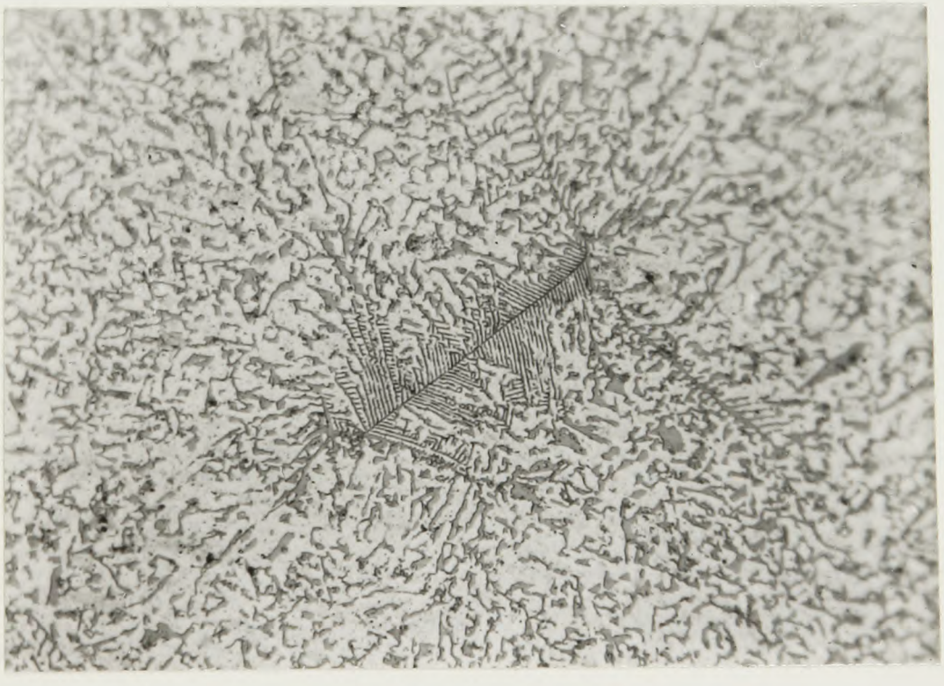
x 460

PLATE 18b Furnace-cooled Ag/Si Eutectic



x 460

PLATE 19a Furnace-cooled Au/Si Eutectic



x 460

PLATE 19b Furnace-cooled Au/Si Eutectic

R cm/sec	G°C/cm	Type	R cm/sec	G°C/cm	Type
2.78×10^{-5}	200	●	1.30×10^{-4}	29.5	⊕
"	120	+	"	16.0	⊕
"	45	+		3.5	⊕
"	29.5	+	2.50×10^{-4}	45	⊕
"	16.0	+	"	29.5	⊕
"	3.5	⊕	"	16.0	⊕
3.70×10^{-5}	29.5	+	3.70×10^{-4}	120	⊙
4.63×10^{-5}	29.5	+	"	45	⊙
6.48×10^{-5}	29.5	+	"	29.5	⊙
1.30×10^{-4}	200	+	"	16.0	⊙
"	120	+	"	3.5	⊙
"	45	+	5.0×10^{-4}	29.5	⊙

KEY: ● = rodlike, + = angular and ⊙ = irregular type of Al/Si eutectic alloy

TABLE 20 - A Selection of Results of Unidirectional Solidification Experiments for Hypoeutectic and Eutectic Al/Si Alloys. (nominal alloy composition of 11.5 wt.% Si, except when $R \geqslant 2.5 \times 10^{-4}$ cm/sec. when 12.5 wt.% Si alloys were used to prevent excessive primary α-Al dendrite formation)

R cm/sec	G°C/cm	Type	R cm/sec	G°C/cm	Type
2.78×10^{-5}	600	⊡	3.70×10^{-4}	45	⊗
"	300	⊡	"	29.5	⊗
"	250	●	"	16.0	⊗
"	200	●	"	3.5	⊙
"	120	+	5.0×10^{-4}	29.5	⊗
"	75	+	6.3×10^{-4}	29.5	⊗
"	45	+	7.41×10^{-4}	120	⊗
"	29.5	+	"	45	⊗
1.30×10^{-4}	3.5	⊕	"	29.5	⊗
2.50×10^{-4}	45	⊛	1.37×10^{-4}	120	⊗
"	29.5	⊛	"	29.5	⊗
3.70×10^{-4}	120	⊗	"	16.0	⊗

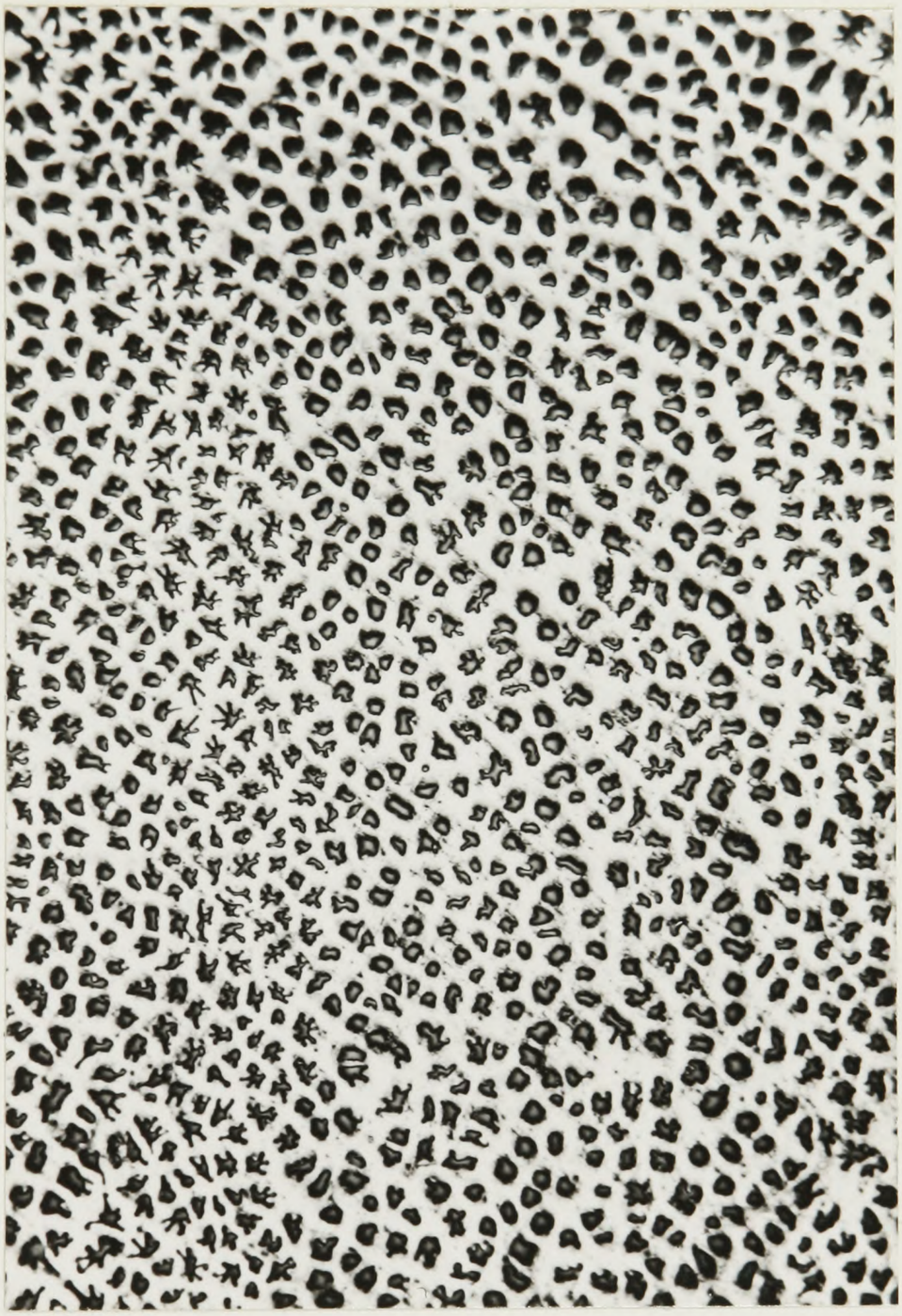
KEY: ⊡ = massive, ● = rodlike, + = angular, ⊙ = irregular and ✕ = complex regular type of Al/Si eutectic alloy.

TABLE 21 - A selection of Results of Unidirectional Solidification Experiments for Hypereutectic Al/Si Alloys. (nominal alloy composition of 15.0 wt.% Si)

x 90

PLATE 22 Massive Al/Si Eutectic - transverse section

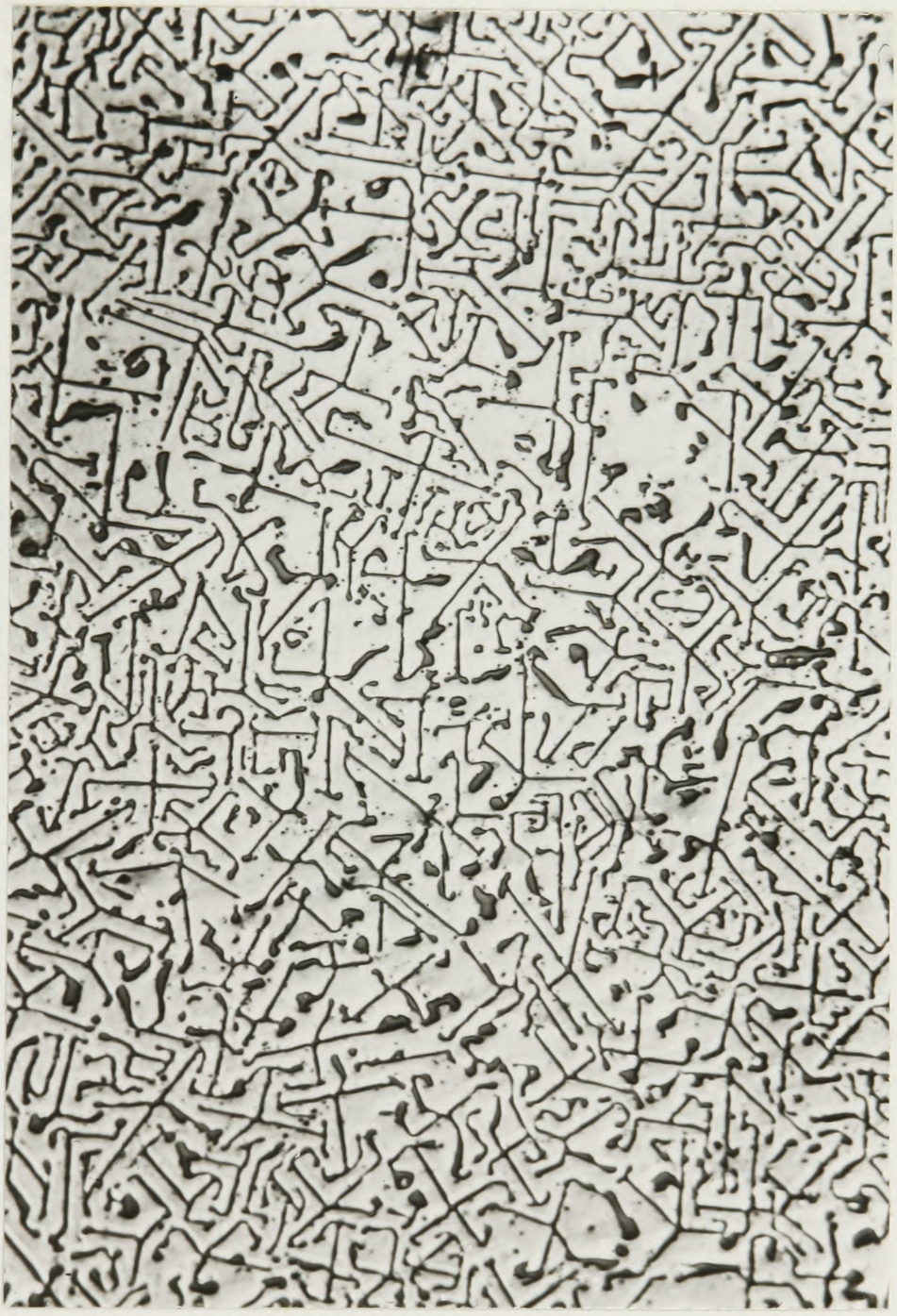
($R = 2.78 \times 10^{-5}$ cm/sec., $G = 600^{\circ}$C/cm.)



x 90

PLATE 23 Rodlike Al/Si Eutectic - transverse section

($R = 2.78 \times 10^{-5}$ cm/sec., $G = 200^{\circ}$C/cm.)



x 90

PLATE 24 Angular Al/Si Eutectic - transverse section

($R = 1.54 \times 10^{-5}$ cm/sec., $G \cong 30^{\circ}C$/cm.)

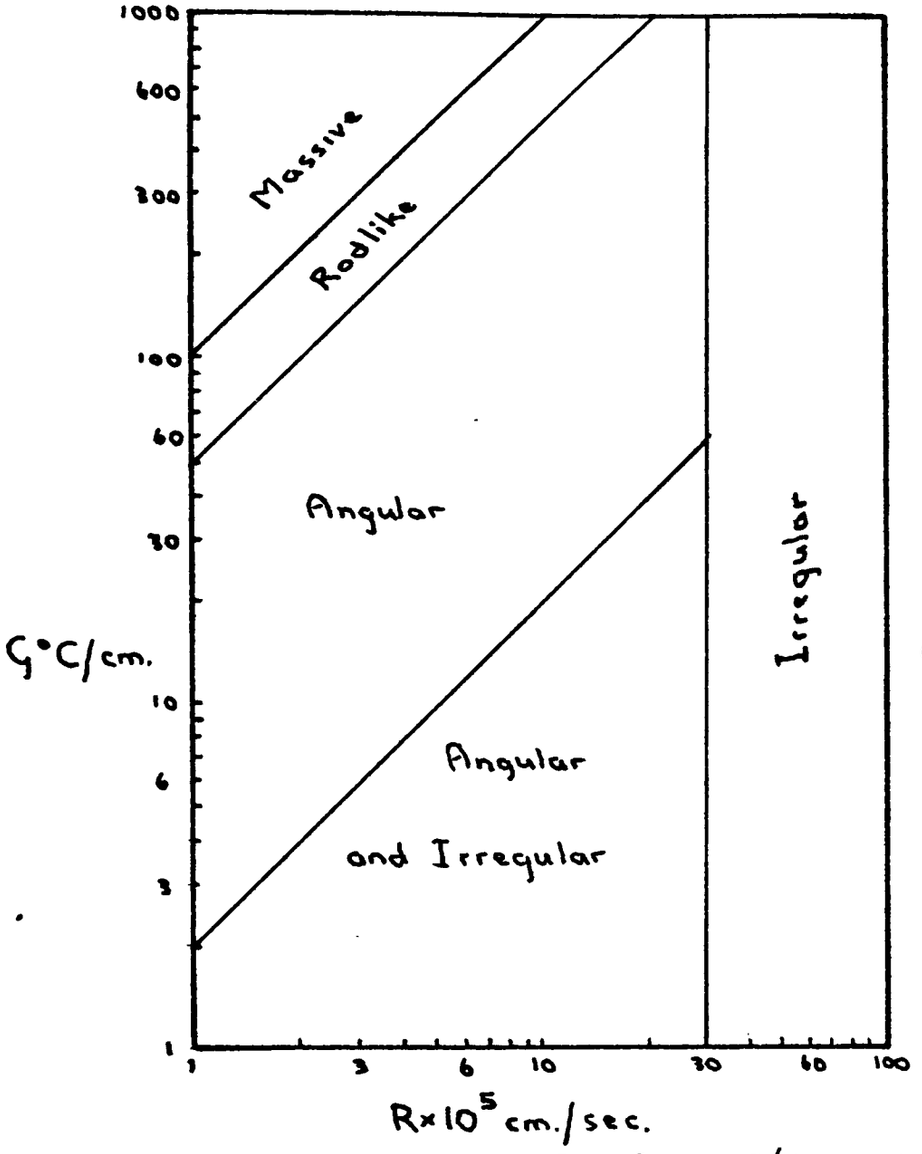
x 190

PLATE 25 Irregular Al/Si Eutectic - transverse section

($R = 7.4 \times 10^{-4}$ cm/sec., $G = 29.5^{\circ}C$/cm.)

x 340

PLATE 26 Complex Regular (Web) Al/Si Eutectic
- transverse section
($R = 3.7 \times 10^{-4}$ cm/sec., $G = 29.5^{\circ}C$/cm.)



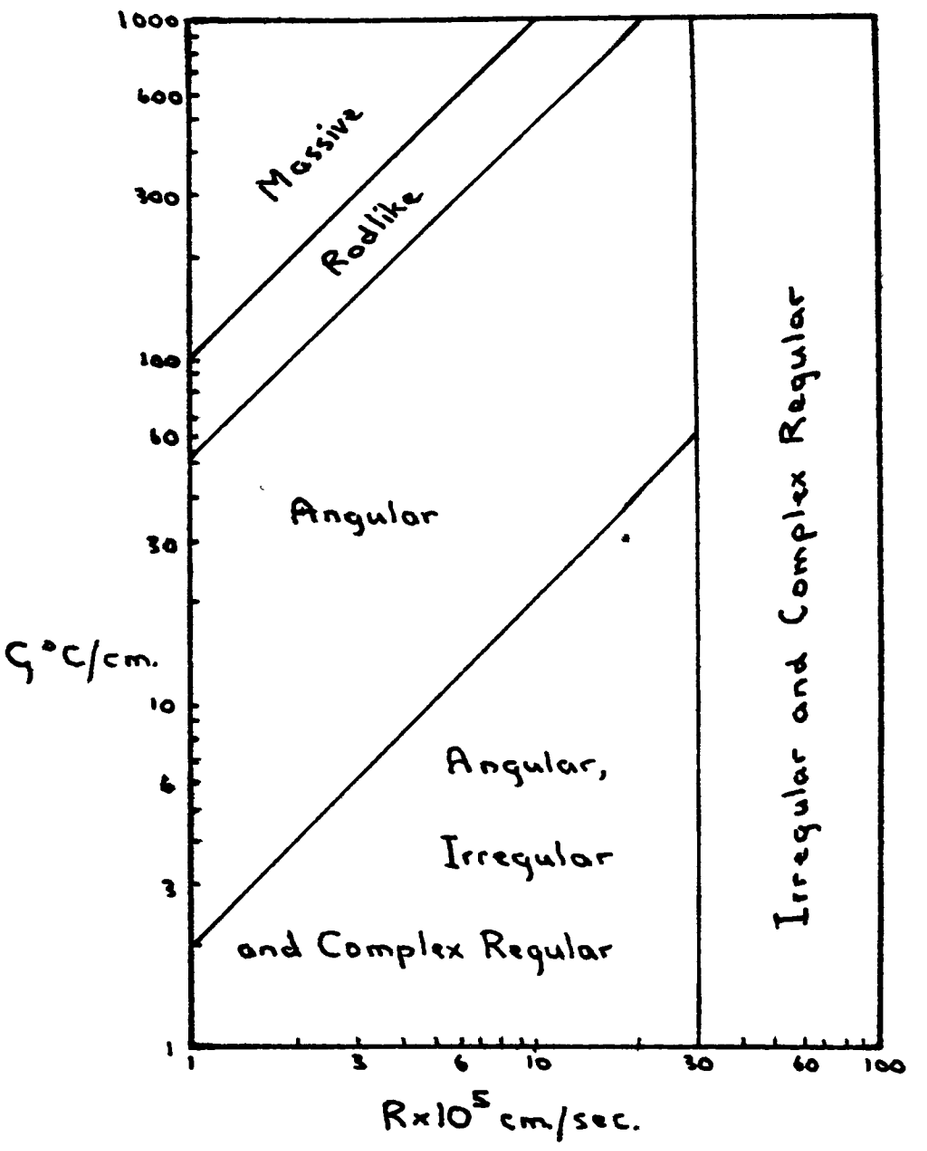


FIG. 27 G/R Morphological Plots

a. Eutectic Al/Si alloys (see table 20)

b. Hypereutectic Al/Si alloys (see table 21)

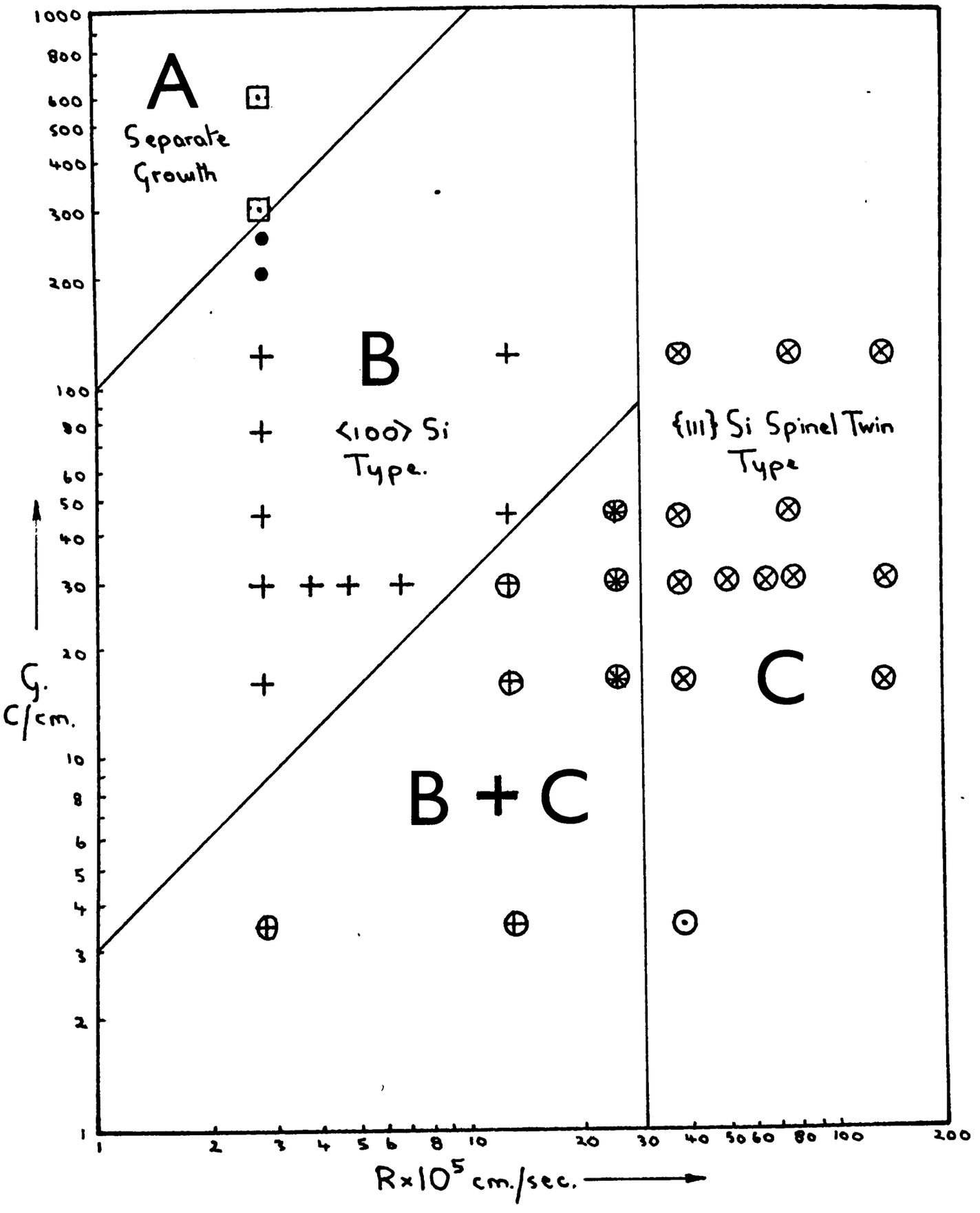


FIG. 28 Growth Mechanism G/R Plot

(hypereutectic results shown - see tables 20 and 21 for key to symbols used)

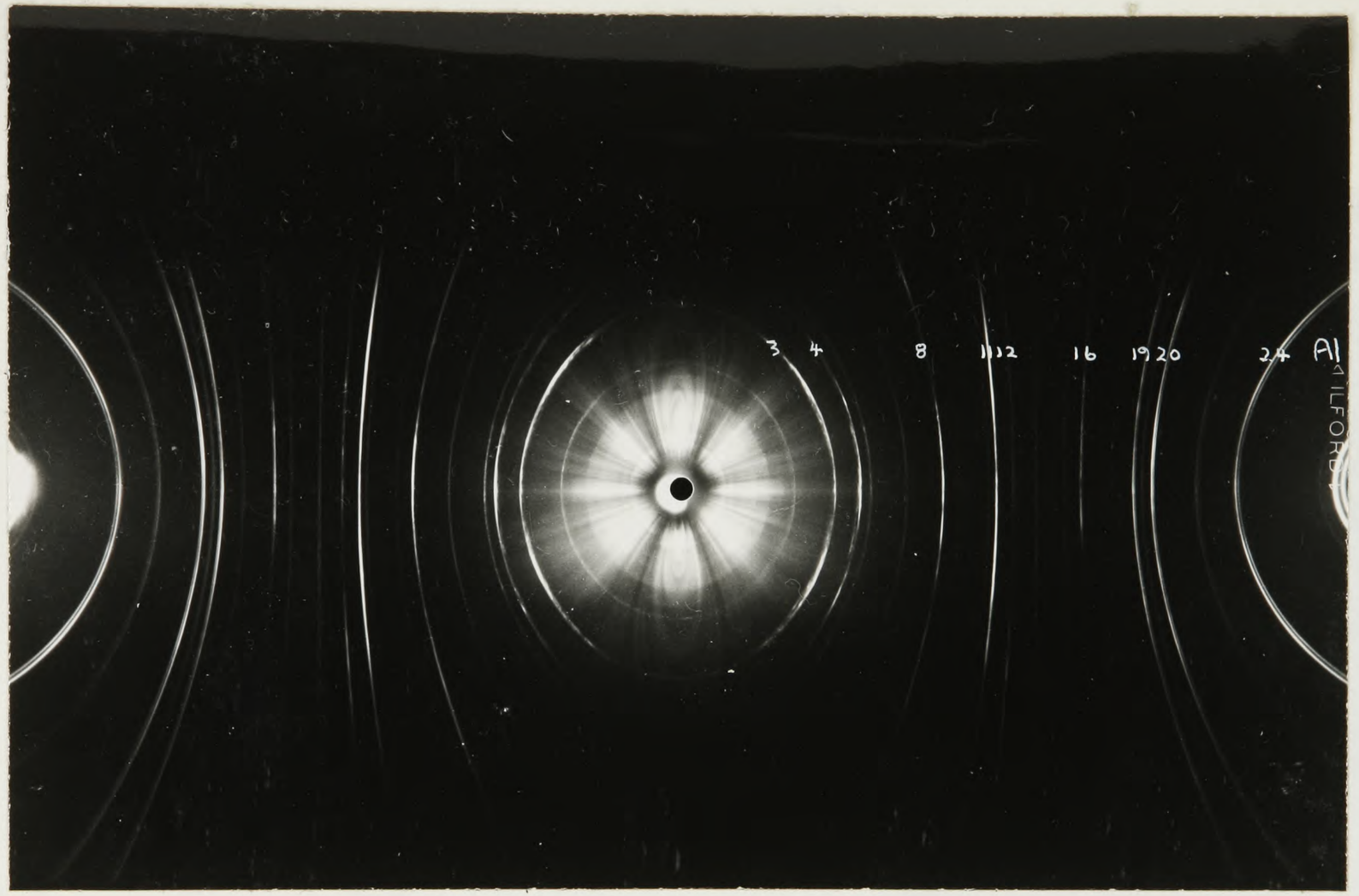


PLATE 29 X-Ray Rotation Photograph (Cu K α radiation) about the Growth Axis of an Al/Si Eutectic Specimen with a Primary α -Al Dendrite.

(R = 3.70 x 10^{-4} cm/sec., G = 16.0^{o}C/cm.)

x 60

PLATE 30 Secondary and Tertiary ⟨100⟩ Arms of an α - Aluminium Dendrite

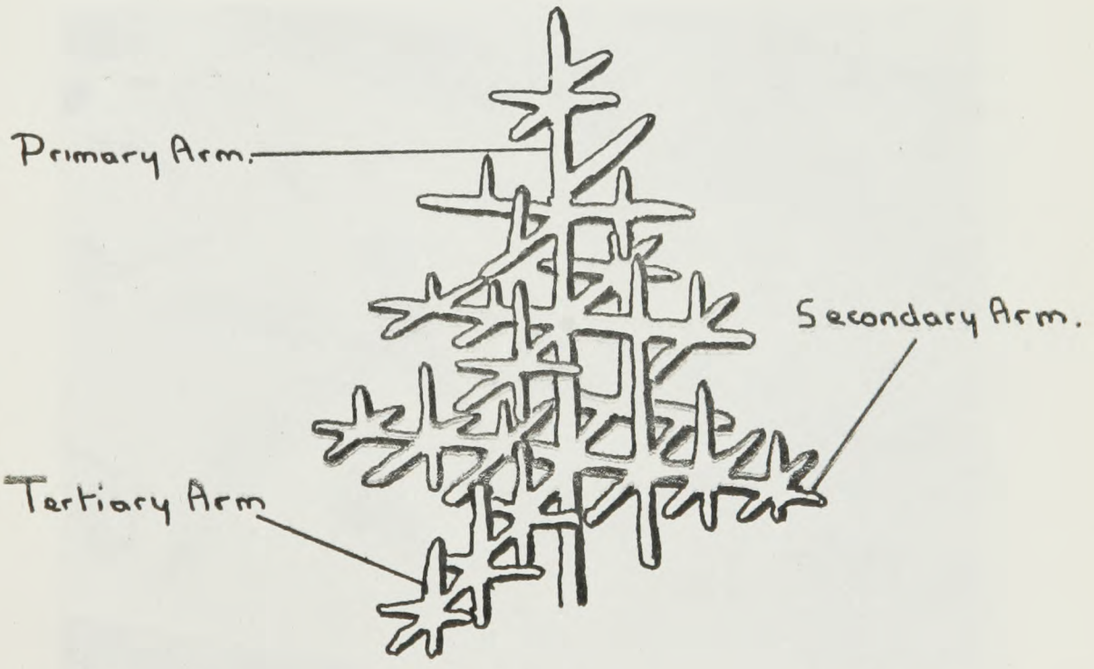


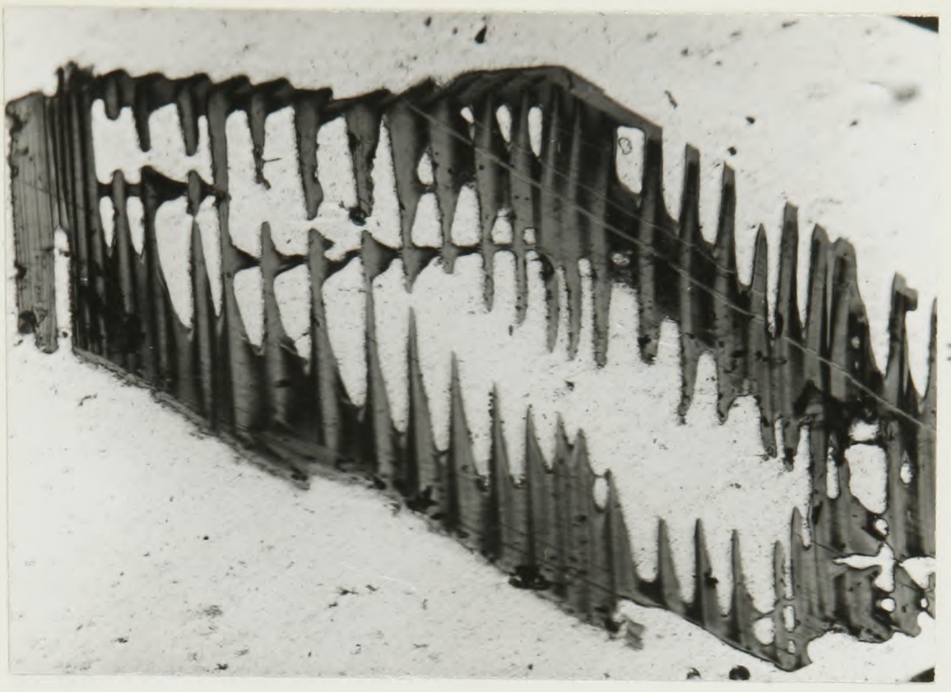
FIG. 30 Sketch of an Extracted Dendrite (after Tschernoff 1868)

x 60

PLATE 31a Al/Si Eutectic - transverse section
($R = 2.78 \times 10^{-5}$ cm/sec. $G = 600^{\circ}C$/cm.)

x 60

PLATE 31b Al/Si Eutectic - longitudinal section
($R = 2.78 \times 10^{-5}$ cm/sec. $G = 600^{\circ}C$/cm.)



x 225

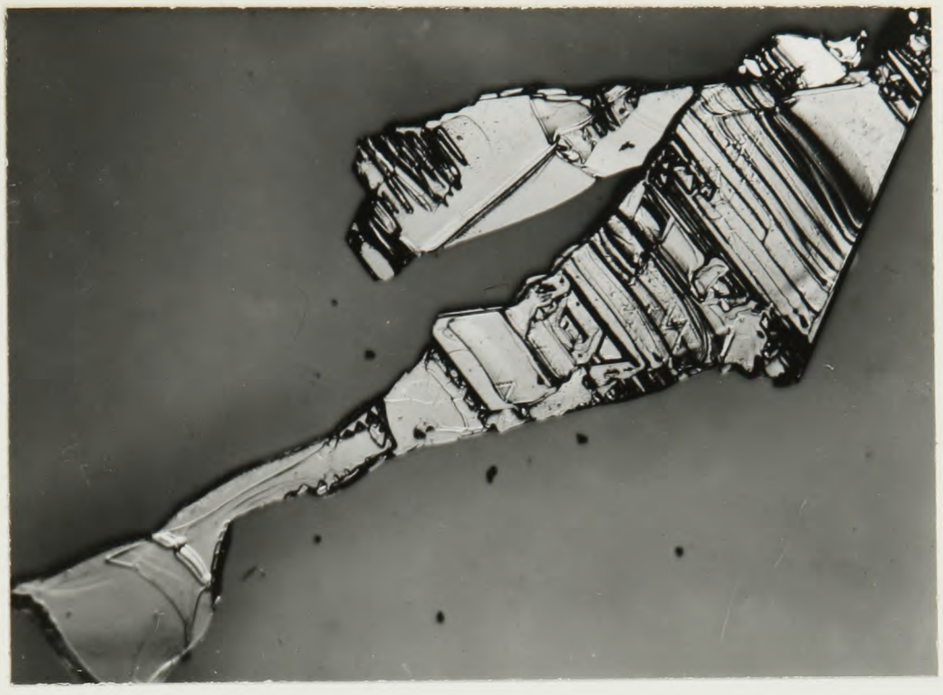
PLATE 32a C.P.4 Etched Al/Si Eutectic-longitudinal section

($R = 2.78 \times 10^{-5}$ cm/sec., $G = 300^{\circ}C$/cm.)

x 460

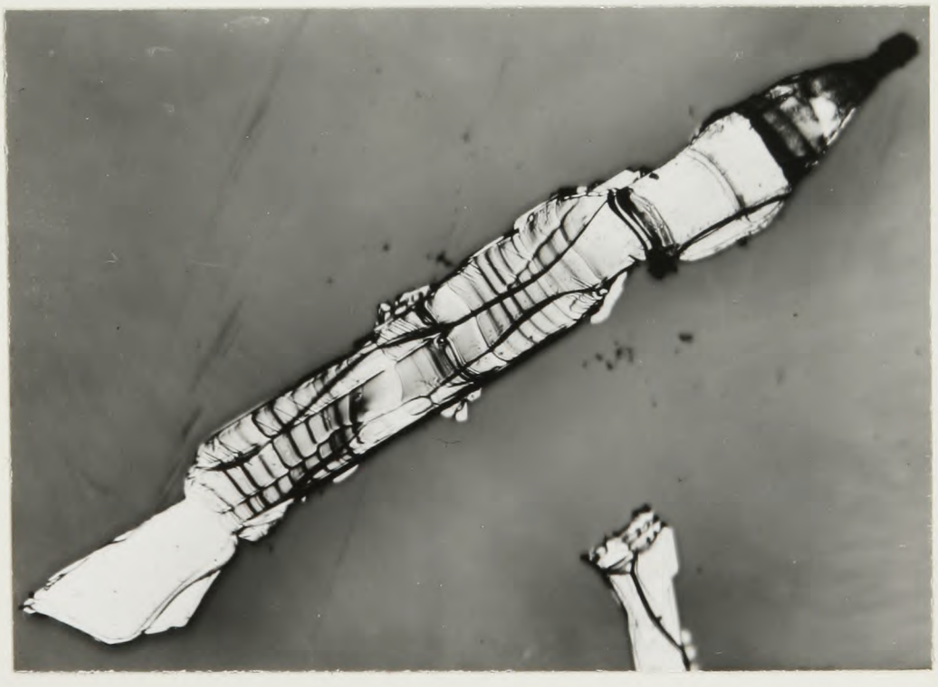
PLATE 32b C.P.4 Etched Al/Si Eutectic - longitudinal section

($R = 2.78 \times 10^{-5}$ cm/sec., $G = 300^{\circ}C$/cm.)



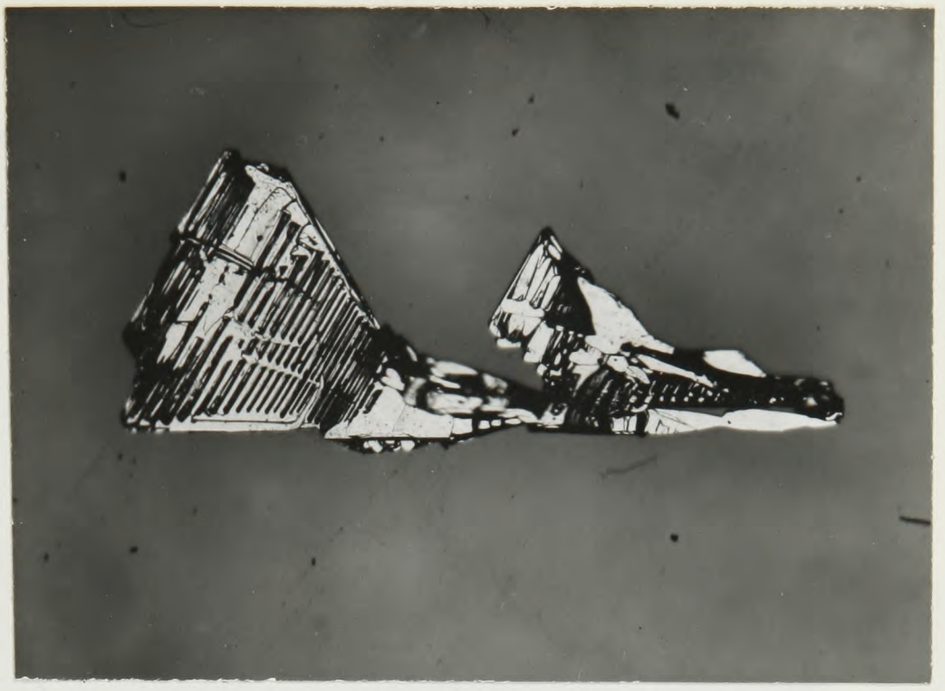
x 60

PLATE 33a Extracted Massive Silicon Particle
($R = 2.78 \times 10^{-5}$ cm/sec., $G = 300^{\circ}C$/cm.)



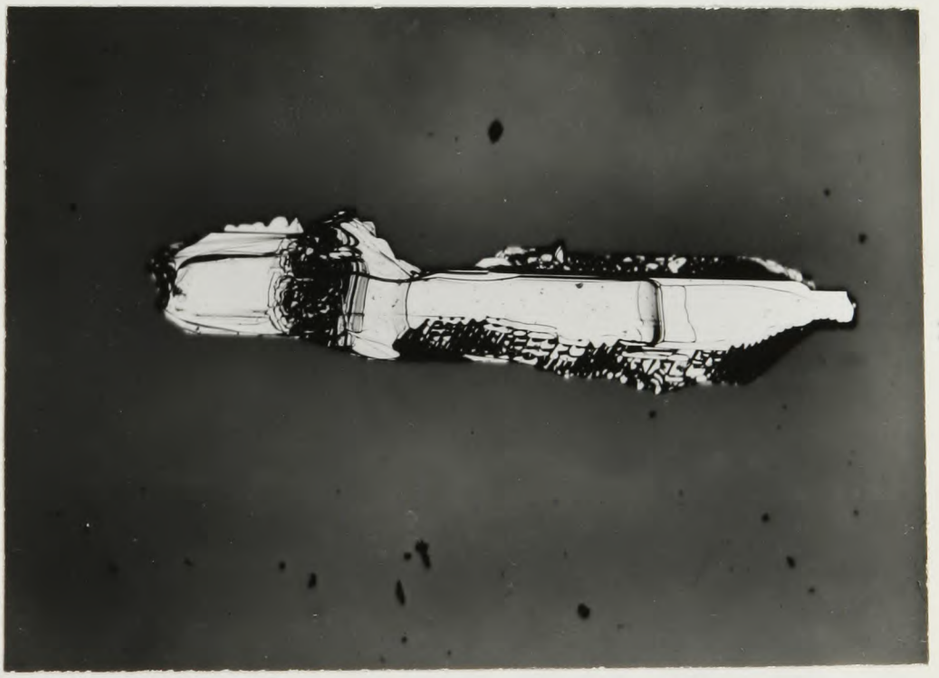
x 60

PLATE 33b Extracted Massive Silicon Particle
($R = 2.78 \times 10^{-5}$ cm/sec., $G = 300^{\circ}C$/cm.)



x 60

PLATE 34a Extracted Massive Silicon Particle
($R = 2.78 \times 10^{-5}$ cm/sec., $G = 300^{\circ}C$/cm.)



x 60

PLATE 34b Extracted Massive Silicon Particle
($R \times 2.78 \times 10^{-5}$ cm/sec., $G = 300^{\circ}C$/cm.)

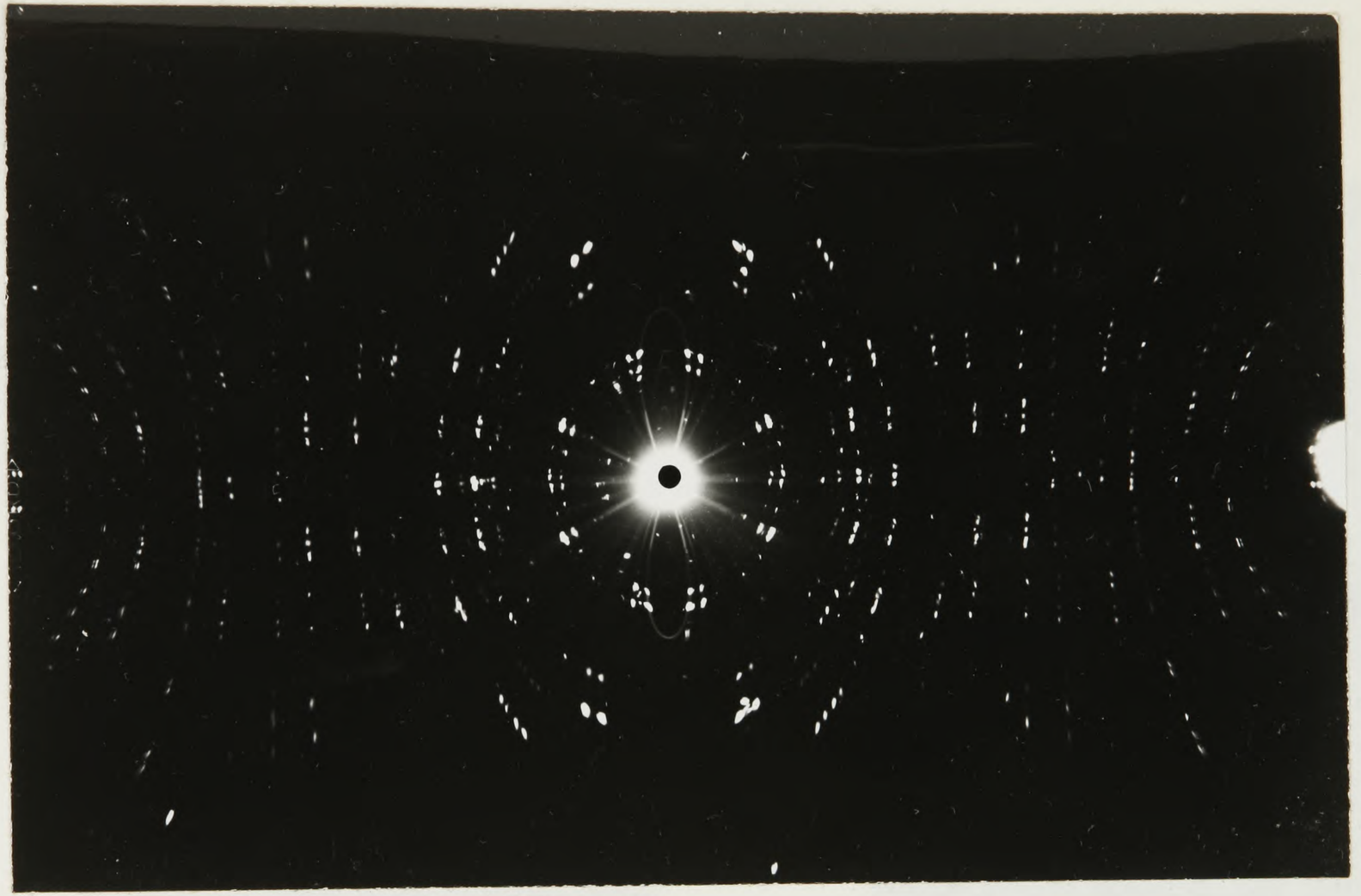
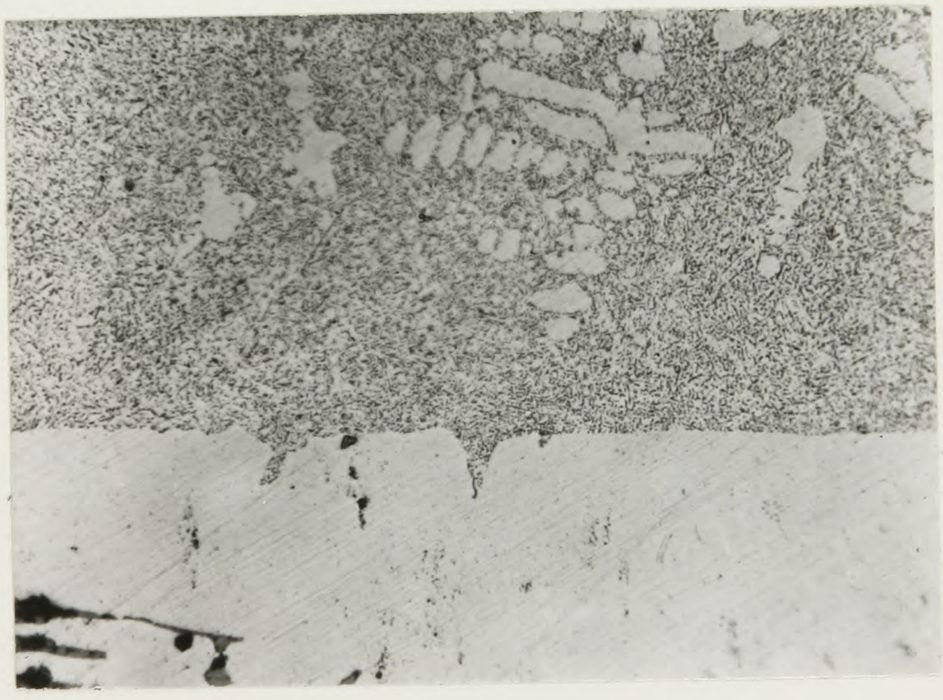


PLATE 35 X-Ray Rotation Photograph (Cu Kα Kβ radiation) Showing a <211> Si preferred orientation

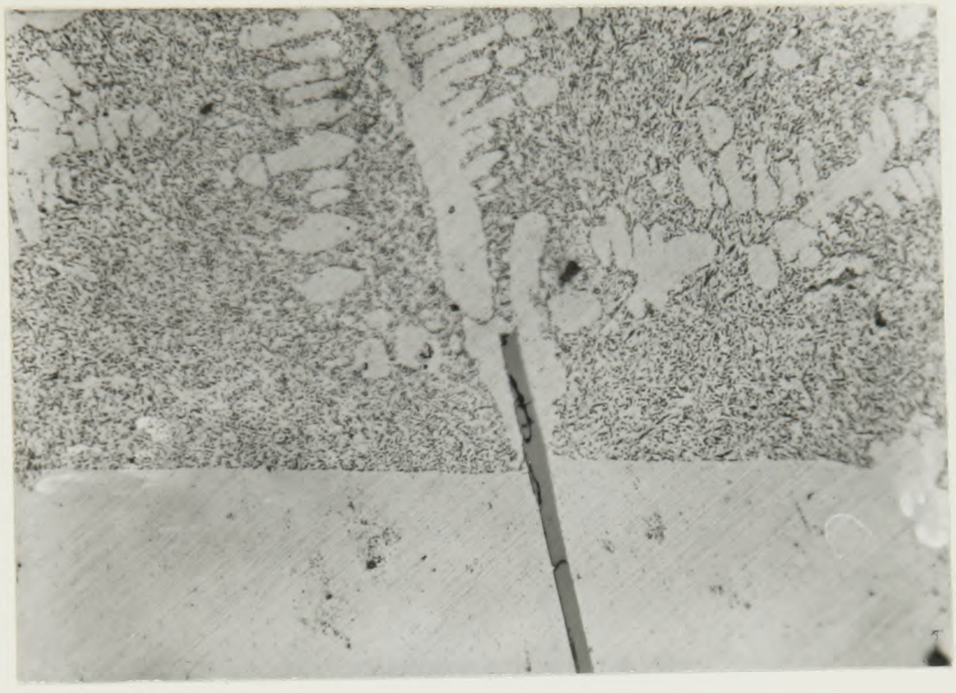
x 60

PLATE 36a Al/Si Eutectic Quenched Growth Front
($R = 2.78 \times 10^{-5}$ cm/sec., $G = 300^{\circ}C$/cm.)



x 460

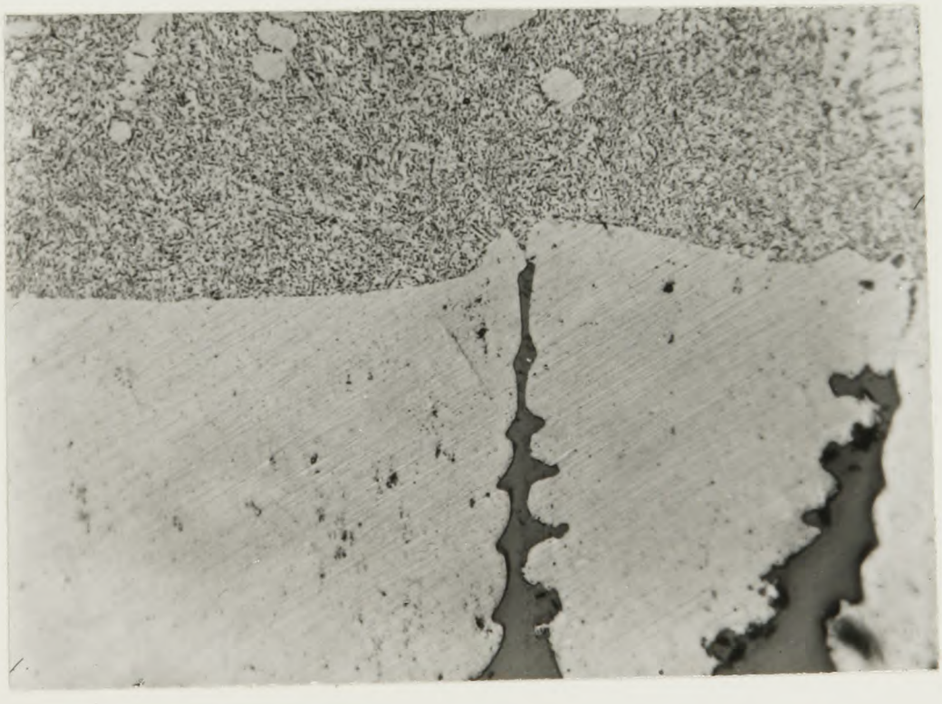
PLATE 36b α-Al Cusp on Quenched Growth Front
(plate 36a)



G.D.

x 460

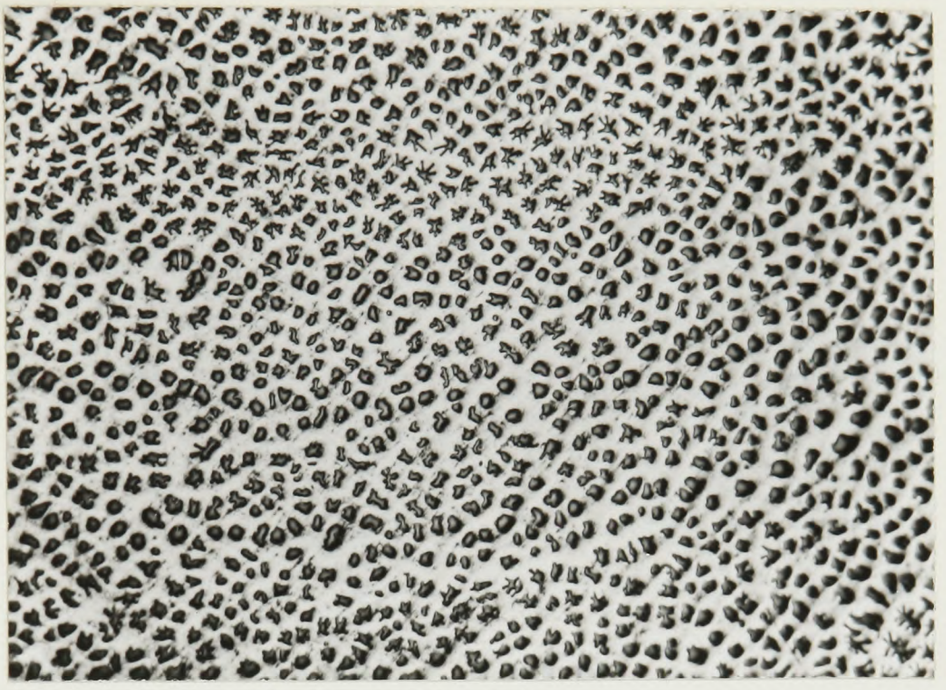
PLATE 37a Si leading at Quenched Growth Front
(plate 36a)



G.D.

x 460

PLATE 37b Si lagging at Quenched Growth Front
(plate 36a)



x 60

PLATE 38a Al/Si Eutectic - transverse section
($R = 2.78 \times 10^{-5}$ cm/sec., $G = 200^{\circ}C$/cm.)

x 60

PLATE 38b Al/Si Eutectic - longitudinal section
($R = 2.78 \times 10^{-5}$ cm/sec., $G = 200^{\circ}C$/cm.)

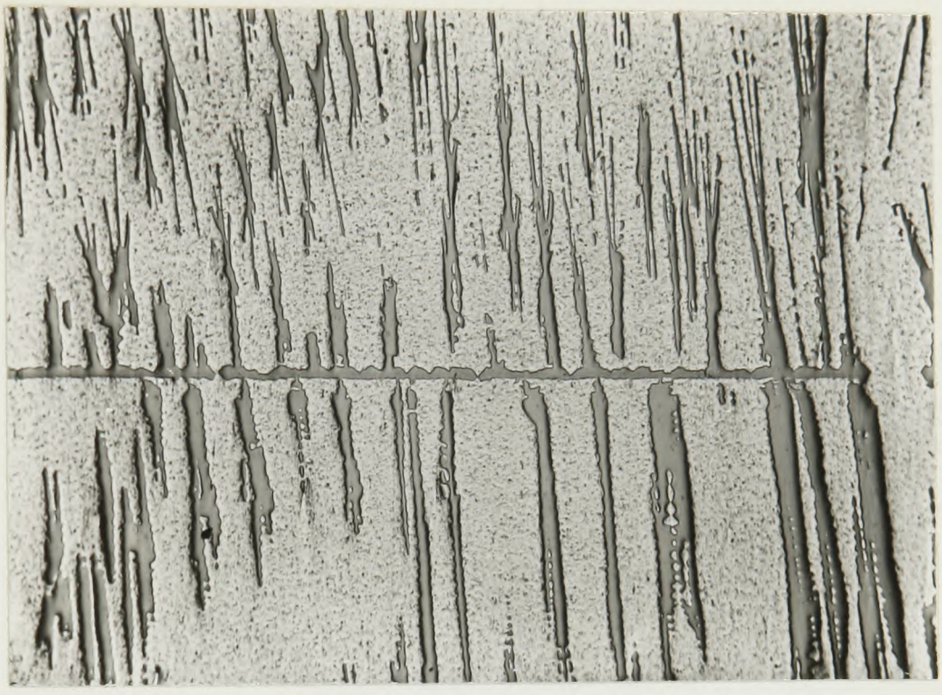


PLATE 39a Si Growth Band - longitudinal section
(R = 2.78 x 10^{-5}cm/sec., G = 200°C/cm.)

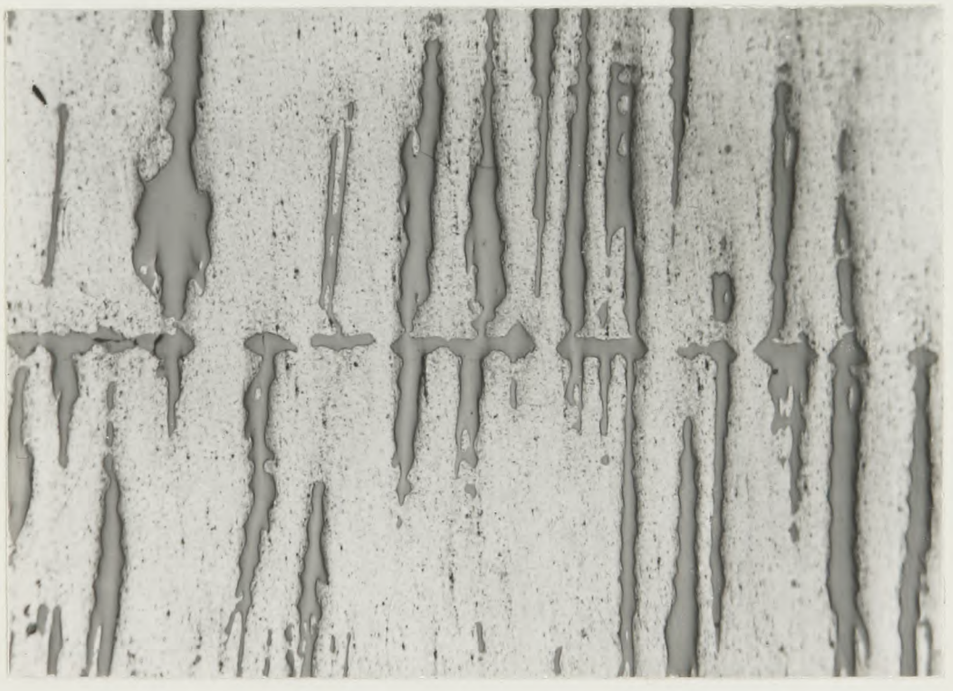
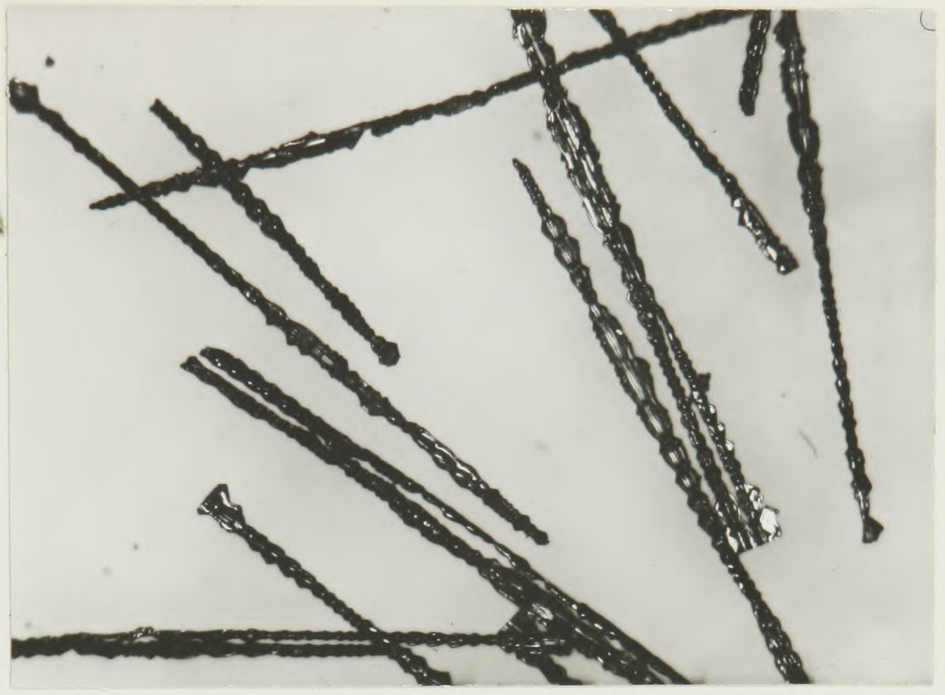


PLATE 39b Si Growth Band - longitudinal section
(R = 2.78 x 10^{-5}cm/sec., G = 200°C/cm.)

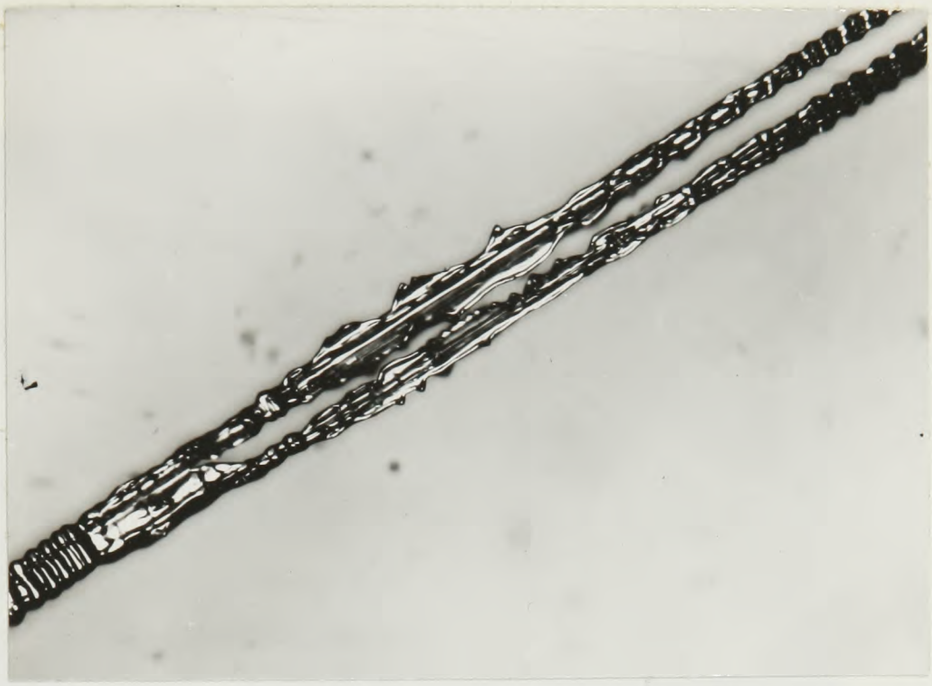


x 60

PLATE 40a Extracted Si fibres (c.f. plates 38)
(R = 2.78 x 10^{-5}cm/sec., G = 200°C/cm.)

x 460

PLATE 40b An Extracted Si fibre
(R =2.78 x 10^{-5}cm/sec., G = 200°C/cm.)



x 125

PLATE 41a A Bifurcated Silicon Fibre
($R = 2.78 \times 10^{-5}$ cm/sec., $G = 200^{\circ}C$/cm.)

x 125

PLATE 41b Silicon Fibres with Side Plates attached
($R = 2.78 \times 10^{-5}$ cm/sec., $G = 200^{\circ}C$/cm.)

PLATE 42 X-Ray Rotation Photograph (Cu K α K β radiation) showing a <1 1 0> Si preferred orientation

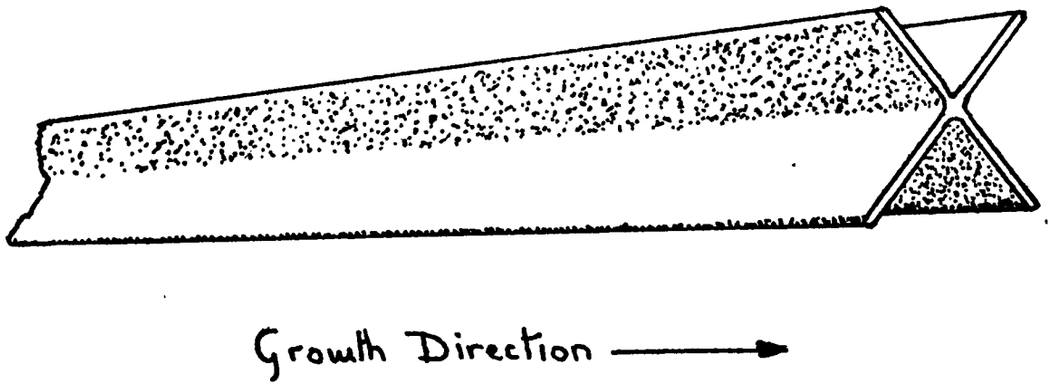
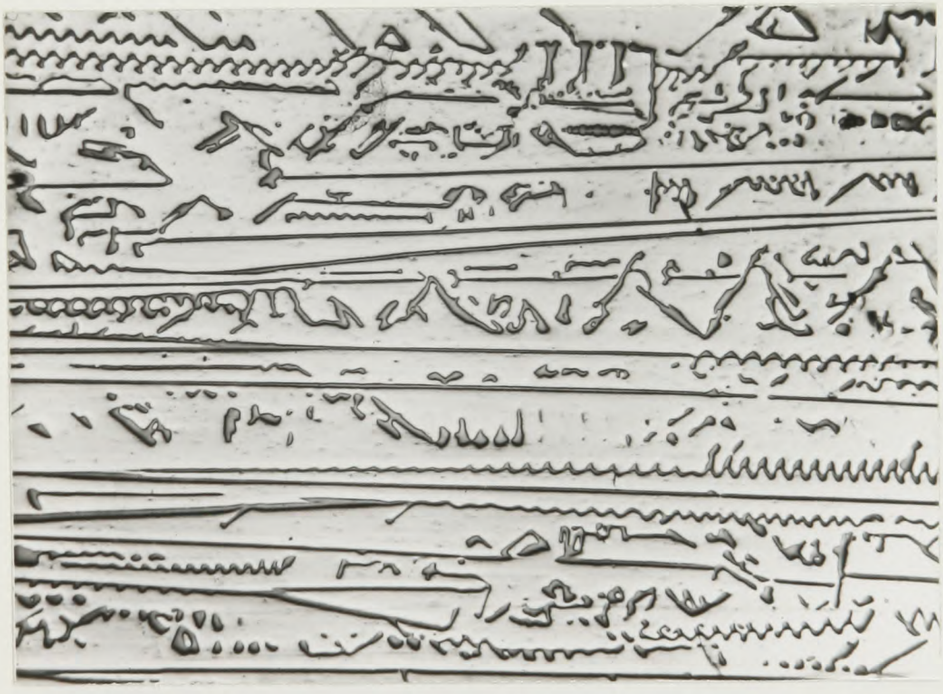


FIG. 43 Model of Extracted Angular Silicon Particle (simplest form)

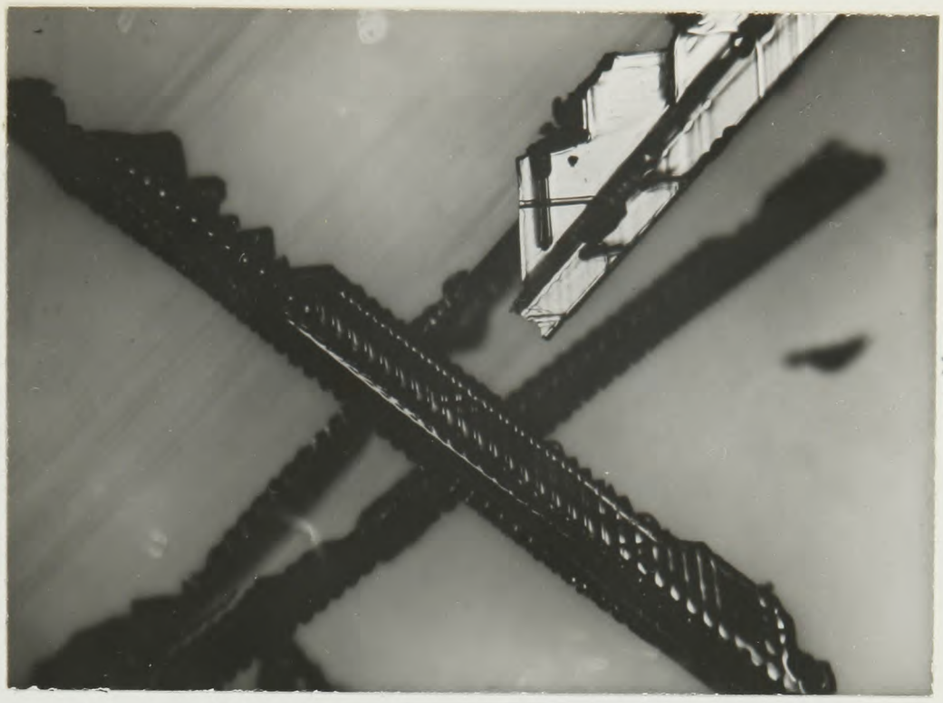
x 60

PLATE 44a Al/Si Eutectic - transverse section
($R = 2.78 \times 10^{-5}$ cm/sec., $G = 16^{\circ}C$/cm.)



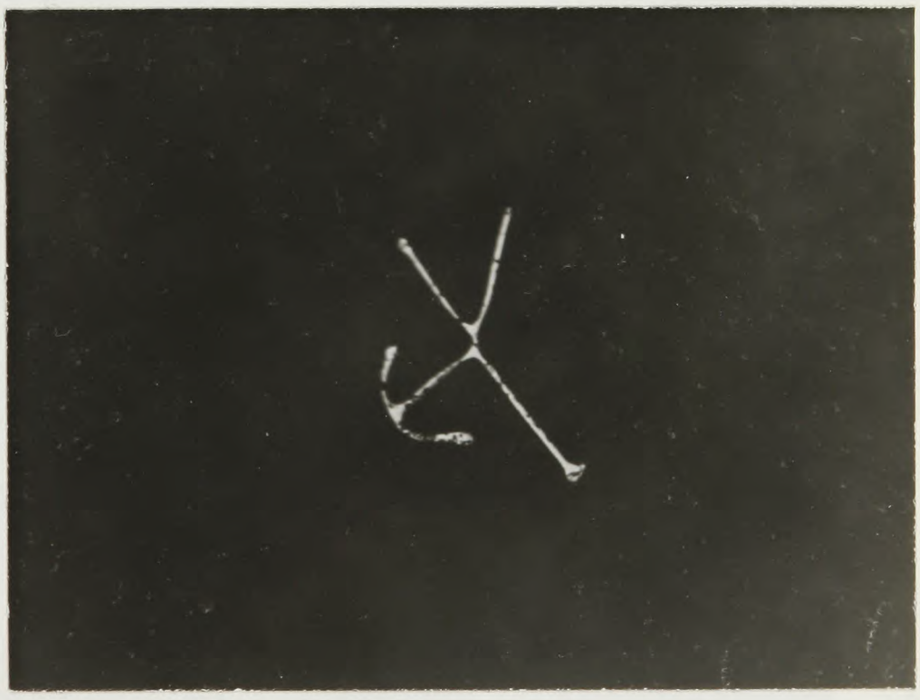
x 60

PLATE 44b Al/Si Eutectic - longitudinal section
($R = 2.78 \times 10^{-5}$ cm/sec., $G = 16^{\circ}C$/cm.)



x 60

PLATE 45a Extracted Angular Silicon Particles
(c.f. plate 60a)
($R = 2.78 \times 10^{-5}$ cm/sec., $G = 29.5^{\circ}$C/cm.)

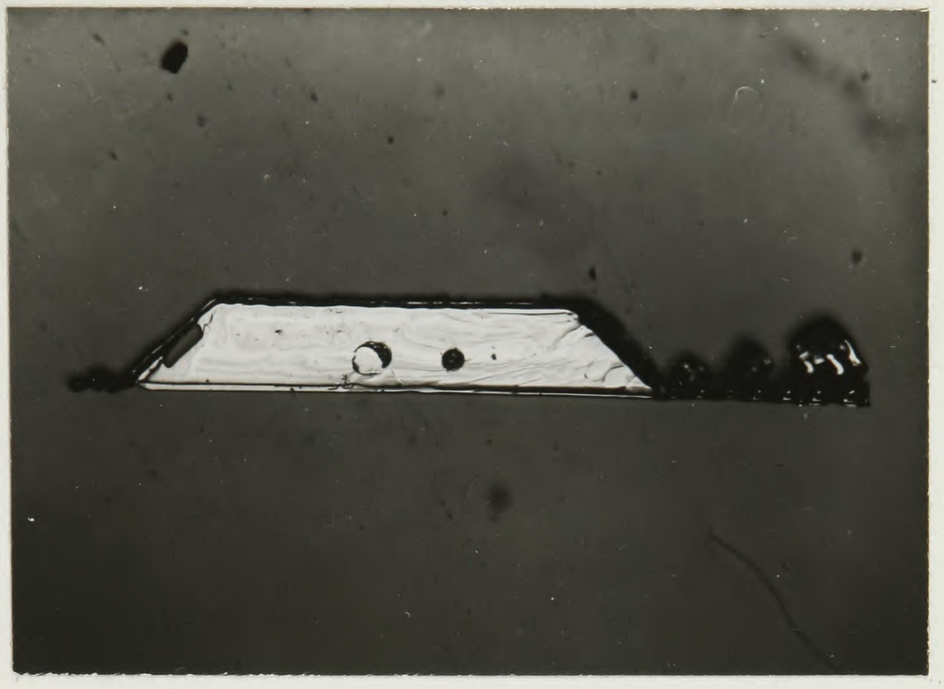


x 225

PLATE 45b End View of an Extracted Angular Si Particle
($R = 1.54 \times 10^{-5}$ cm/sec., $G \cong 30^{\circ}$C/cm.)

PLATE 46 X-Ray Rotation Photograph (Cu Kα radiation) about the Growth Axis of an Al/Si Eutectic Specimen

($R = 2.76 \times 10^{-5}$ cm/sec., $G = 29.5^{\circ}$C/cm.)



x 125

PLATE 47 Extracted Smooth Silicon Plate
($R = 1.54 \times 10^{-5}$ cm/sec. $G \cong 30^{\circ}C/cm.$)

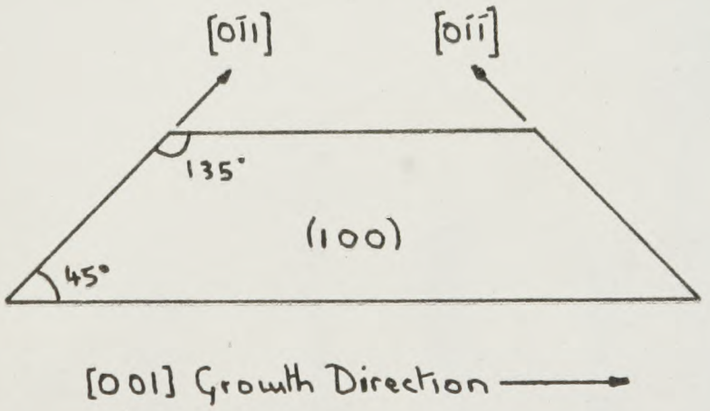
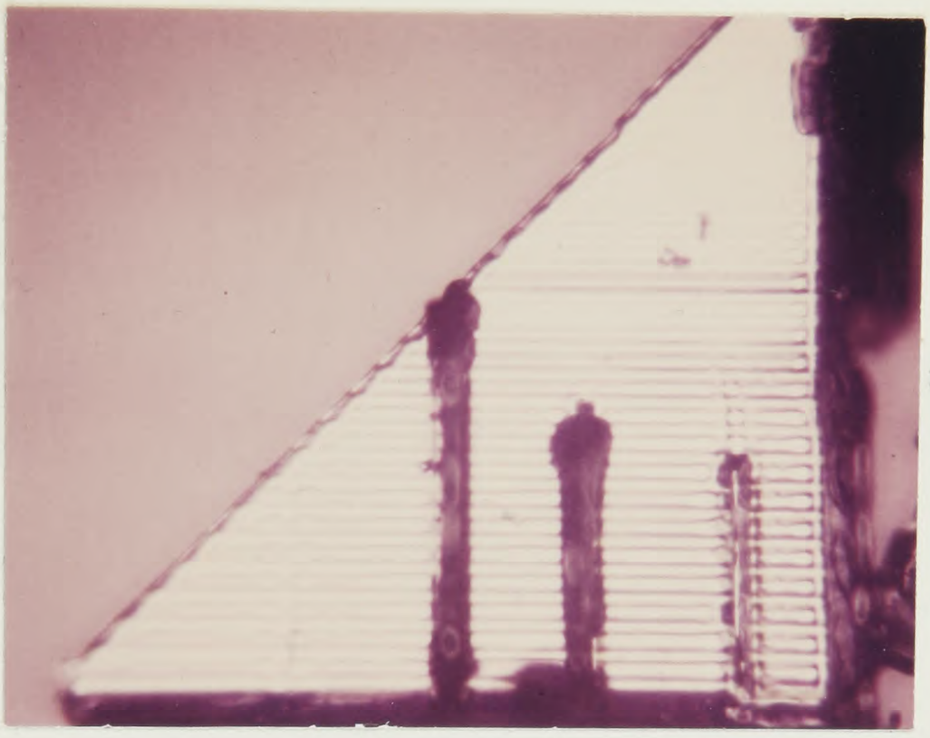


FIG. 47 Crystallography of Smooth Silicon Side Plates

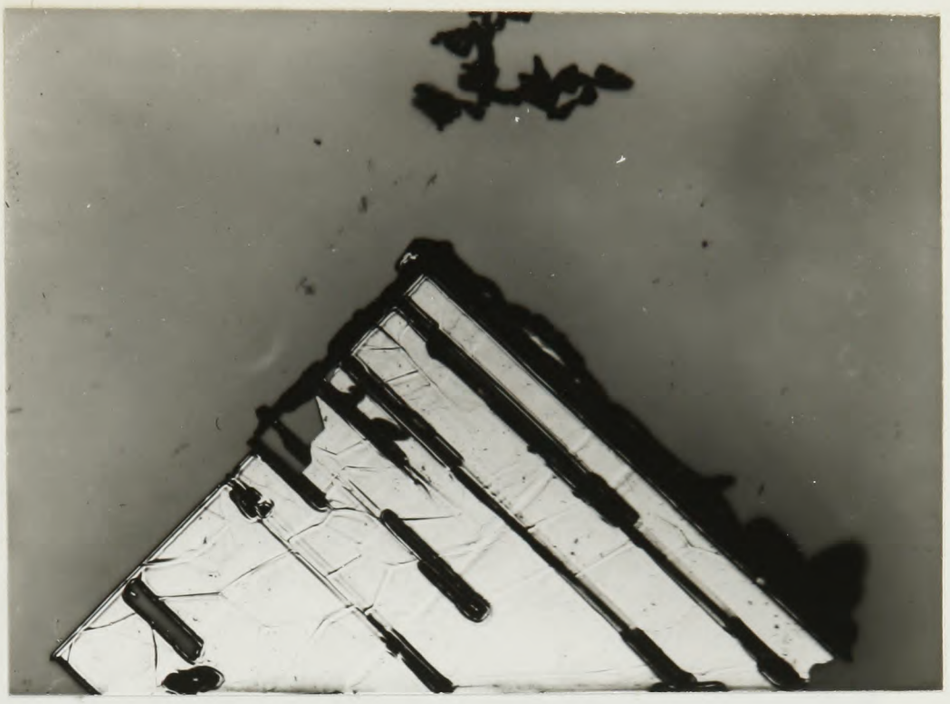


x 125

PLATE 48a Surface-marked Si side plate (reflected light)
($R = 2.78 \times 10^{-5}$ cm/sec., $G = 3.5^{\circ}$C/cm.)

x 125

PLATE 48b Surface-marked Si side plate
(transmitted light)
($R = 2.78 \times 10^{-5}$ cm/sec., $G = 3.5^{\circ}$C/cm.)



x 60

PLATE 49a Extracted Smooth Silicon Side Plate
($R = 2.78 \times 10^{-5}$ cm/sec., $G = 3.5^{\circ}$C/cm.)

x 225

PLATE 49b Extracted Smooth Silicon Side Plate
($R = 2.78 \times 10^{-5}$ cm/sec., $G = 3.5^{\circ}$C/cm.)

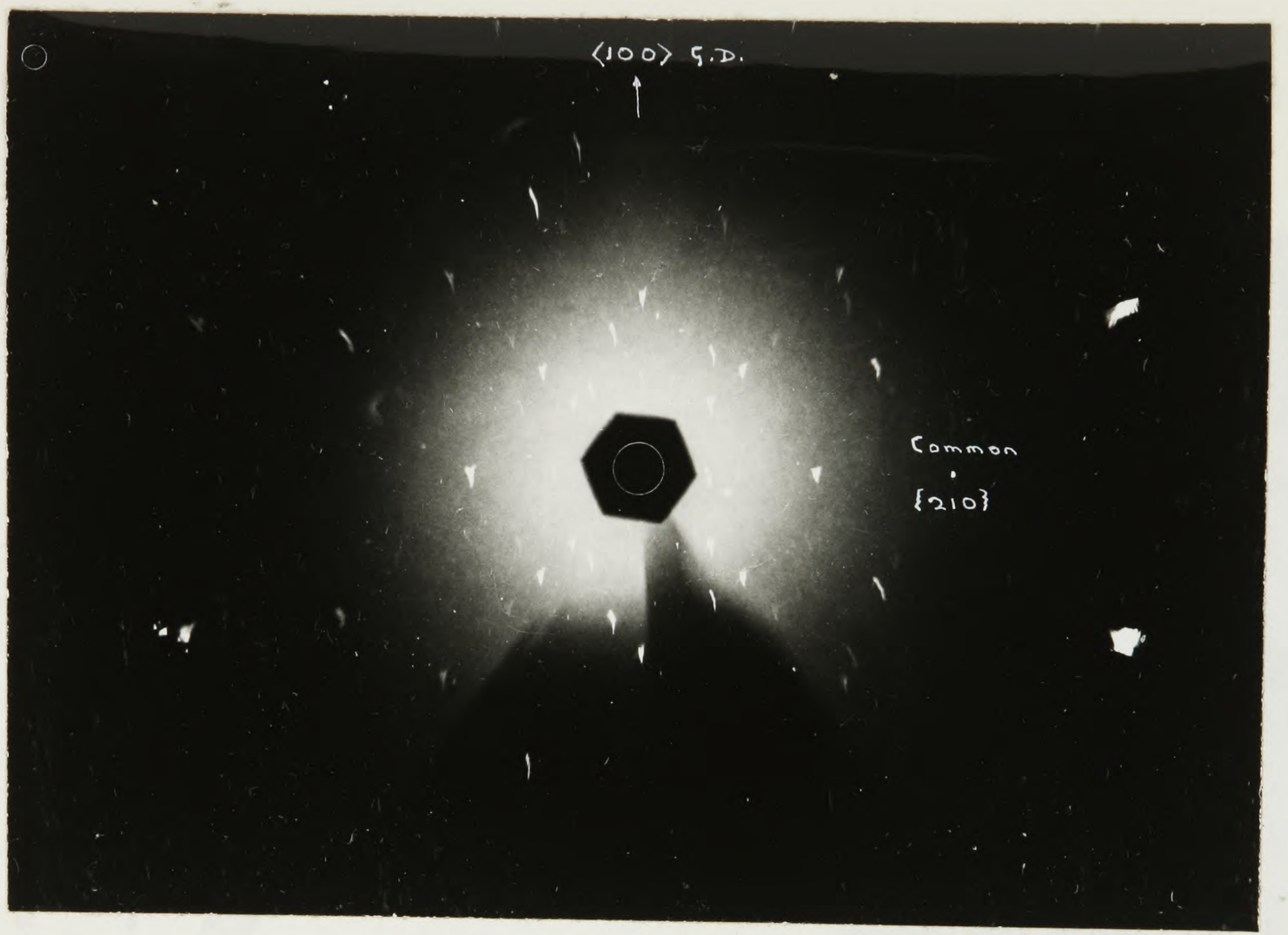
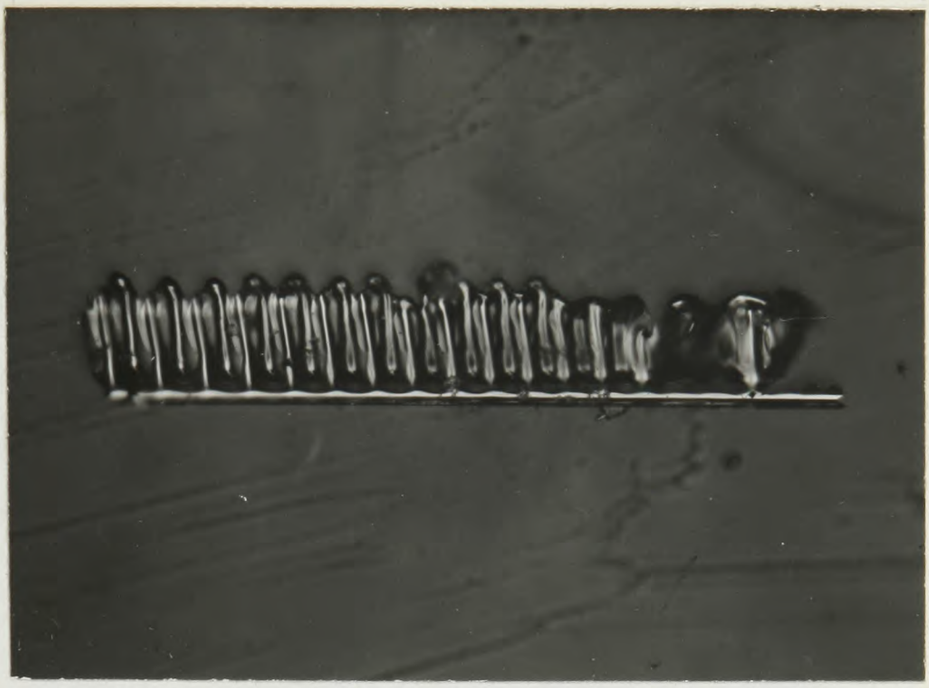


PLATE 50 X-Ray Laue Photograph taken normal to a {100} Smooth Side Plate of a {210} Spinel Twinned Extracted Silicon Particle



x 225

PLATE 51 Extracted Corrugated Silicon Plate
($R = 1.54 \times 10^{-5}$ cm/sec. $G = 30^{\circ}C/cm.$)

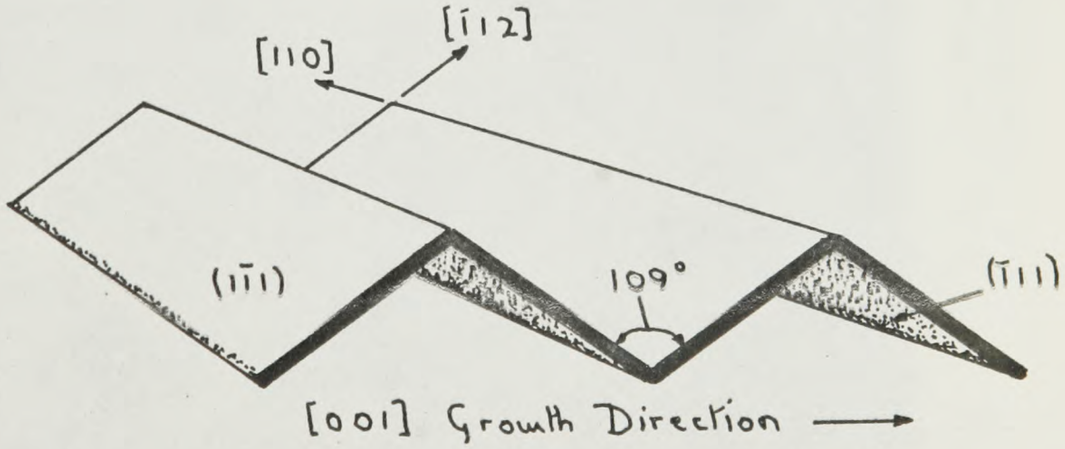


FIG. 51 Crystallography of Corrugated Silicon Side Plates

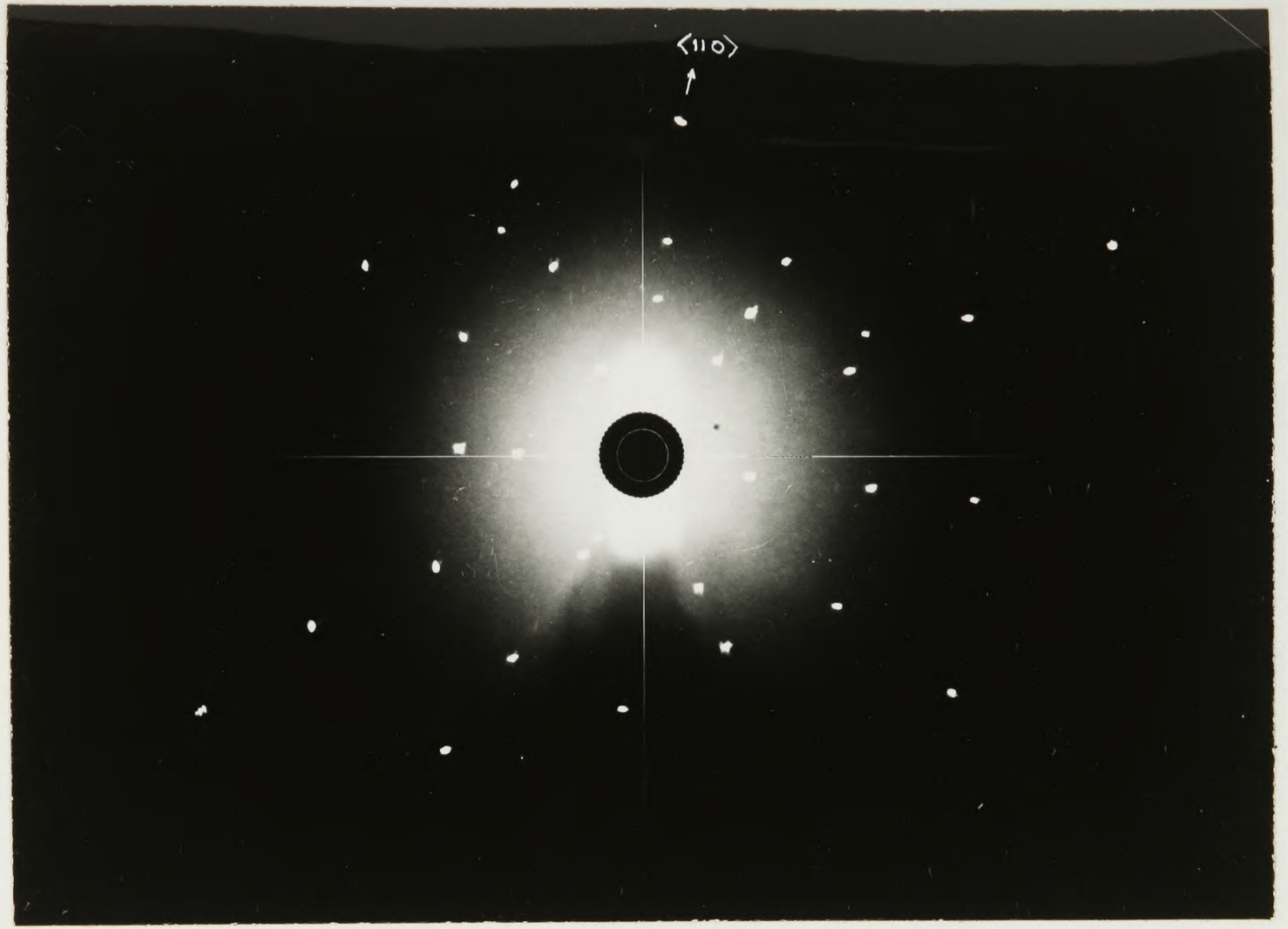


PLATE 52 X-Ray Laue Photograph taken normal to a {111} of a Corrugated Side Plate

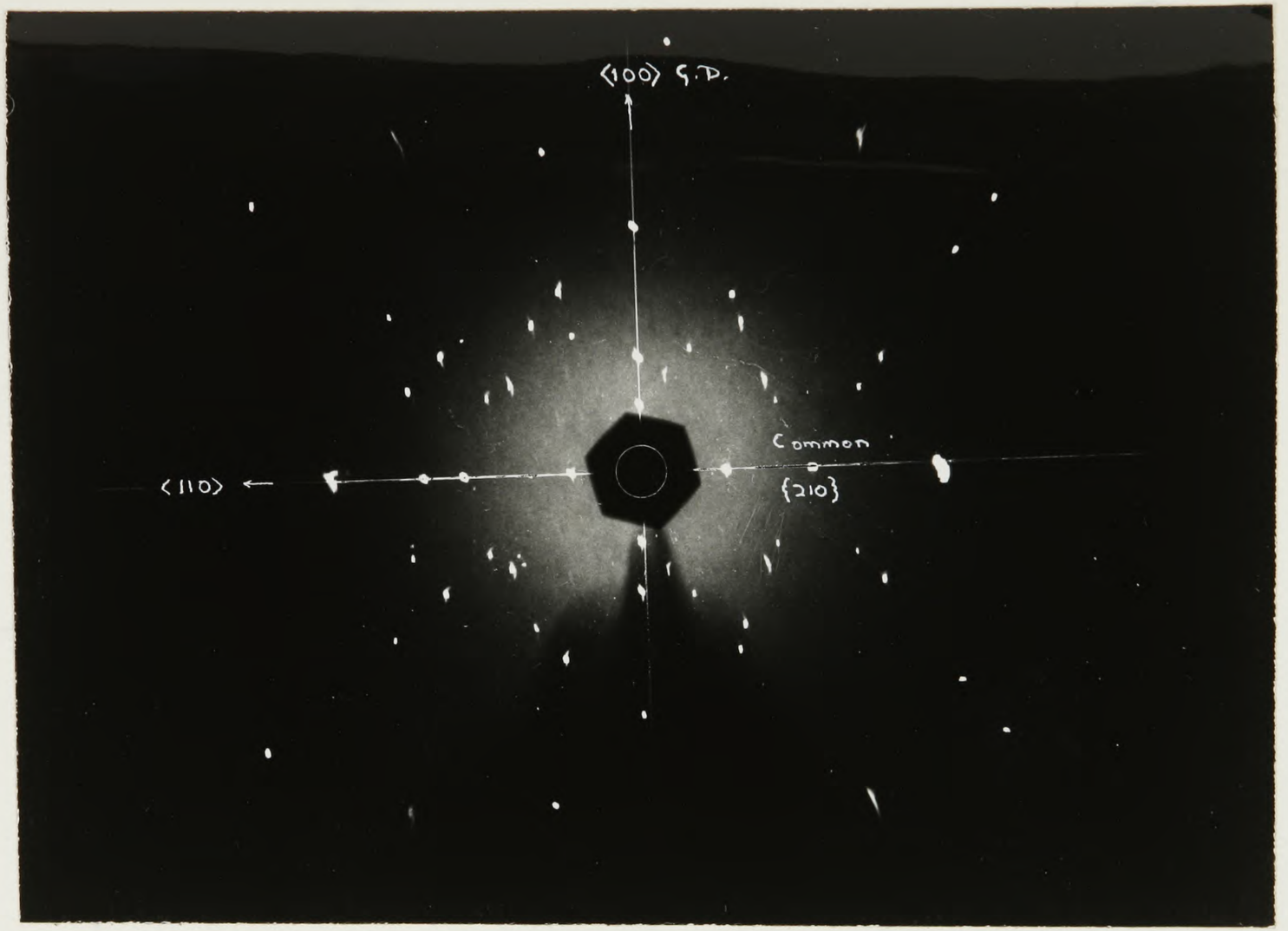


PLATE 53 X-Ray Laue Photograph taken normal to a {110} Corrugated Side Plate of a {210} Spinel Twinned Extracted Angular Silicon Particle

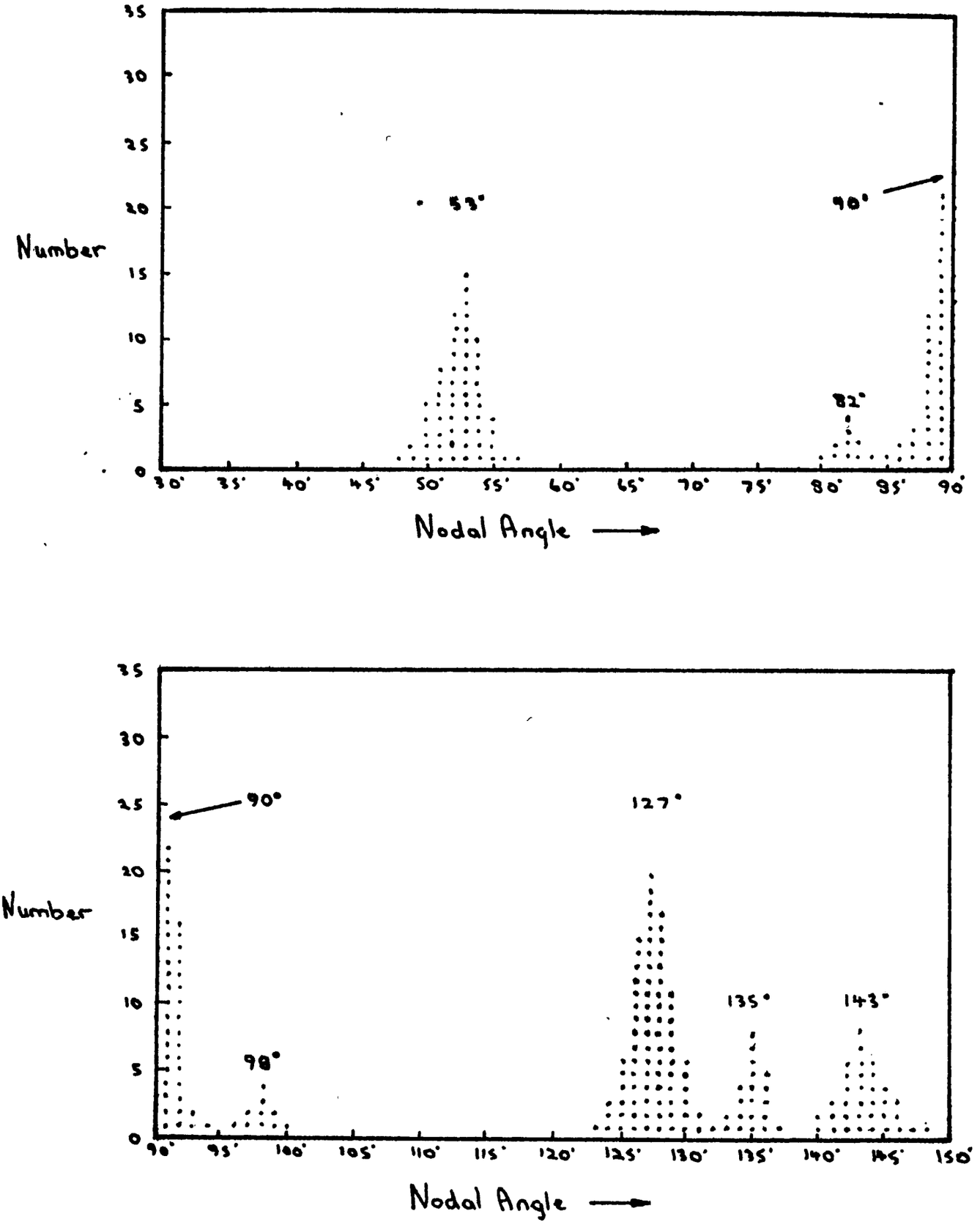


FIG. 54 Angular Silicon Particles - Nodal Angle Histogram (transverse sections)

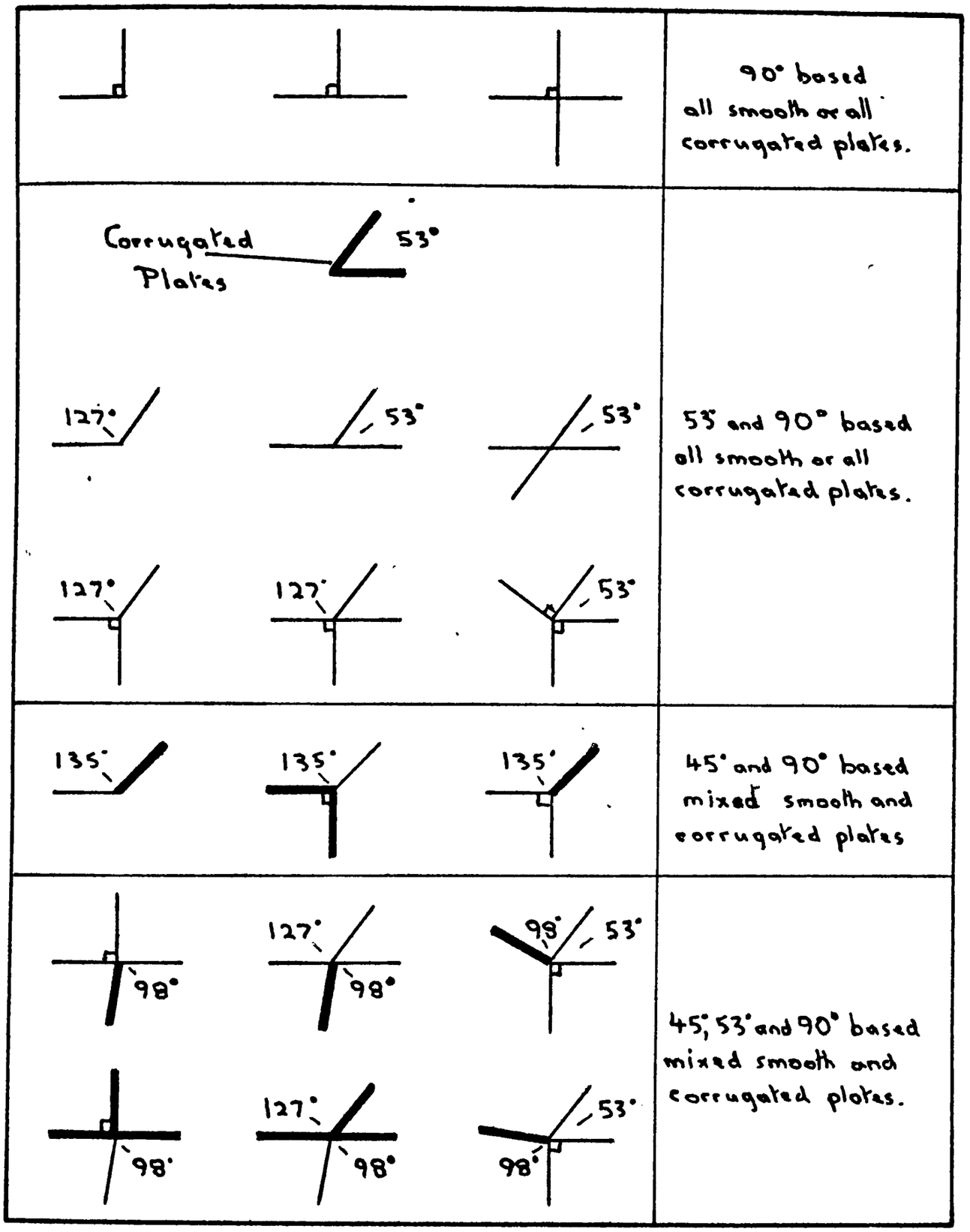


FIG. 55 Angular Silicon Particles - Nodal Types (transverse sections)

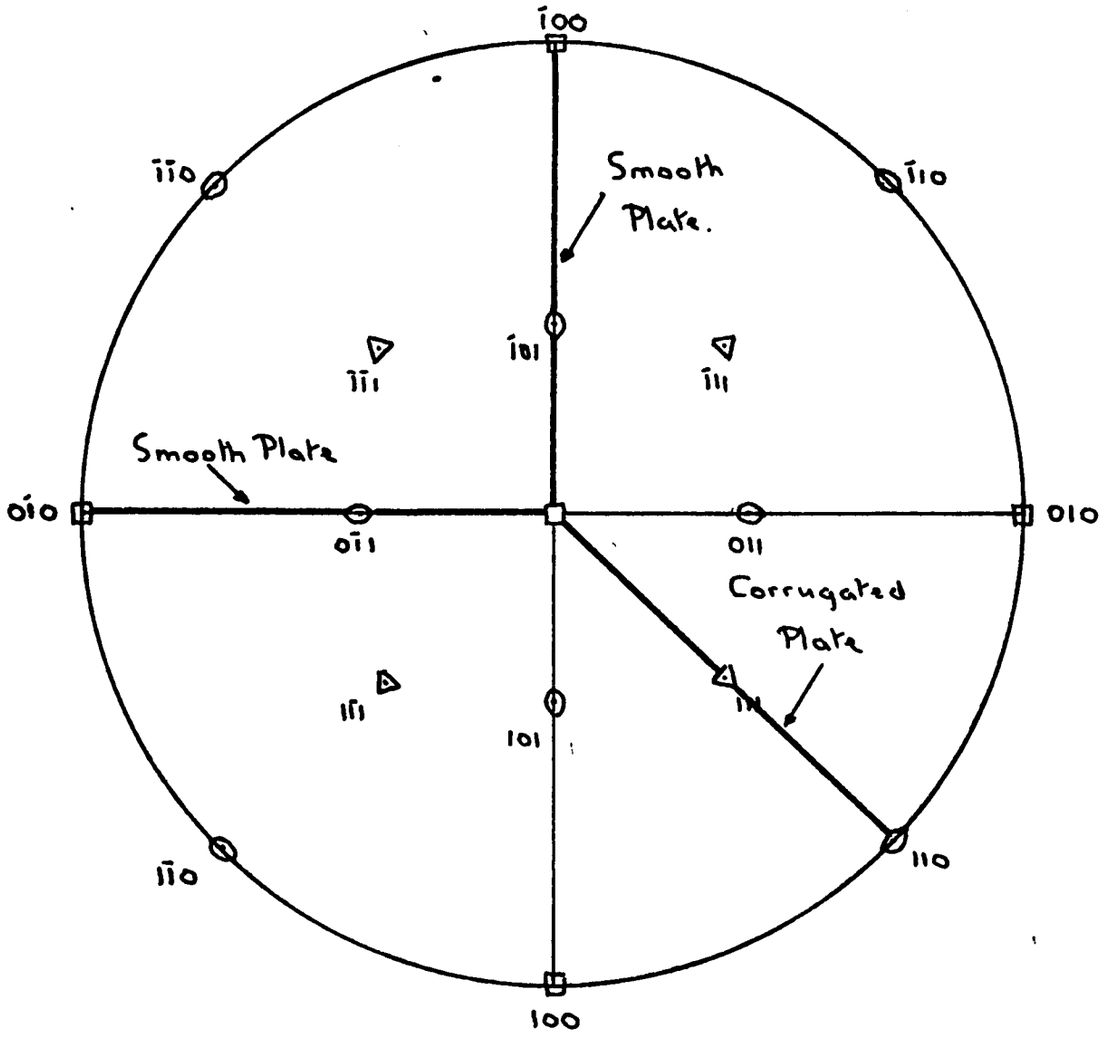


FIG. 56 [001] Stereographic Projection

(Growth direction of angular silicon particle = [001] and the thick line traces represent the side plates of the particle, see figs. 55 and 119)

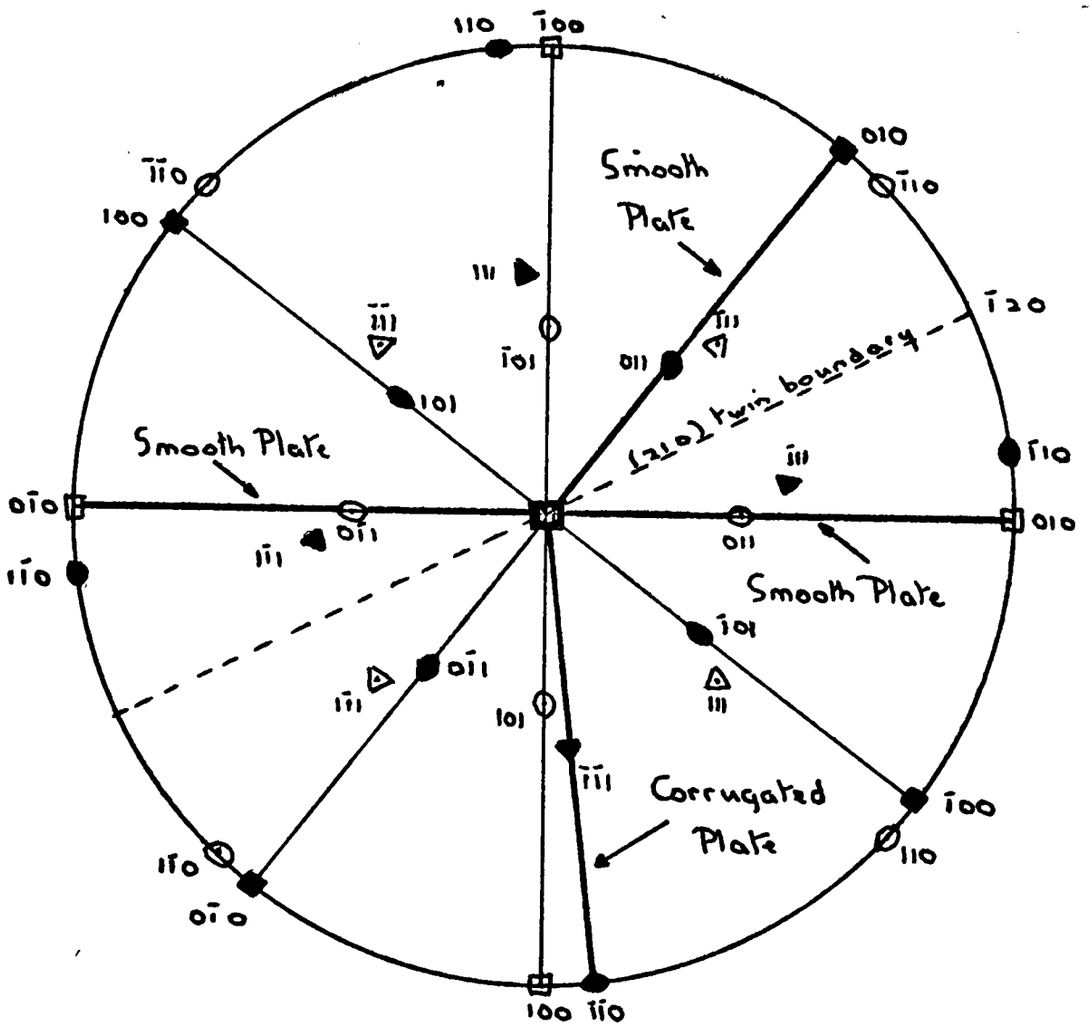
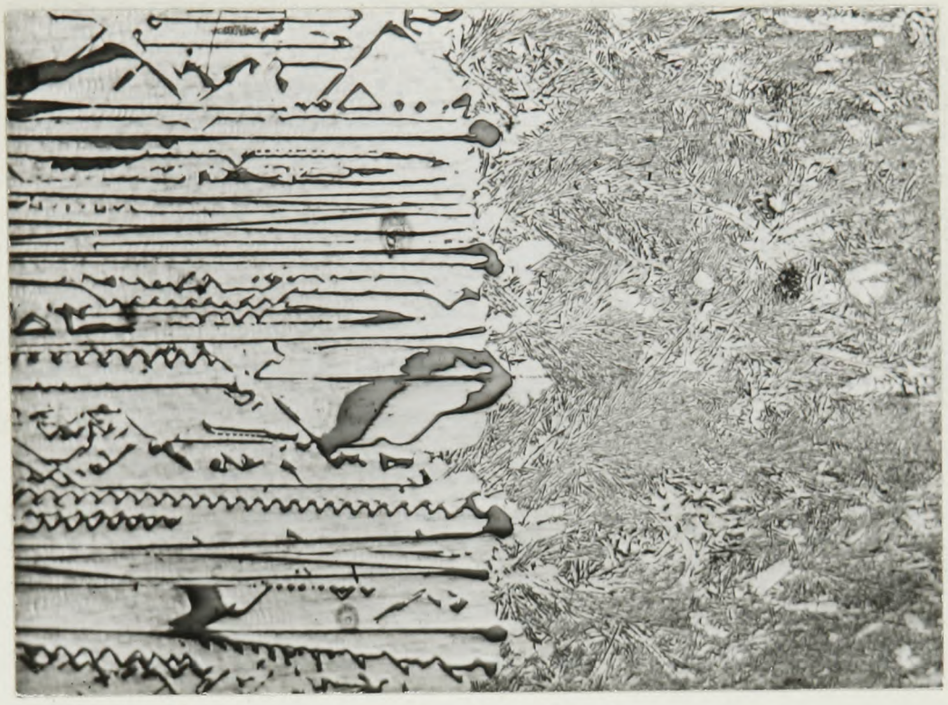


FIG. 57 [001] Stereographic Projection with a (210) Spinel Twin

(Growth direction of angular silicon particle = [001] and the thick line traces represent the side plates of the particle, see fig. 55)



x 60

PLATE 58 Al/Si Quenched Growth Front
($R = 2.78 \times 10^{-5}$ cm/sec., $G = 29.5^{\circ}C$/cm.)

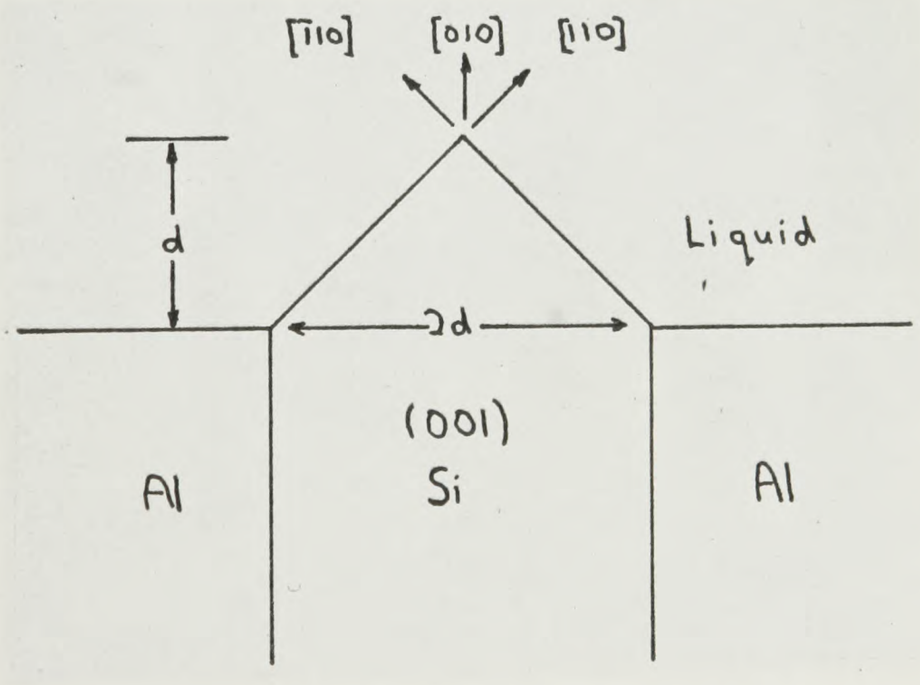
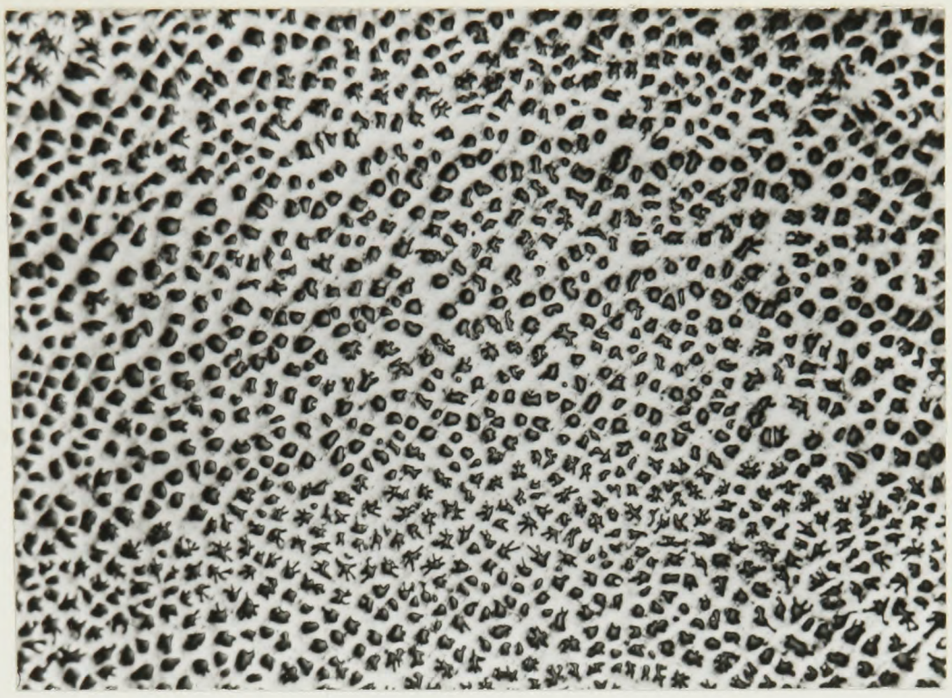
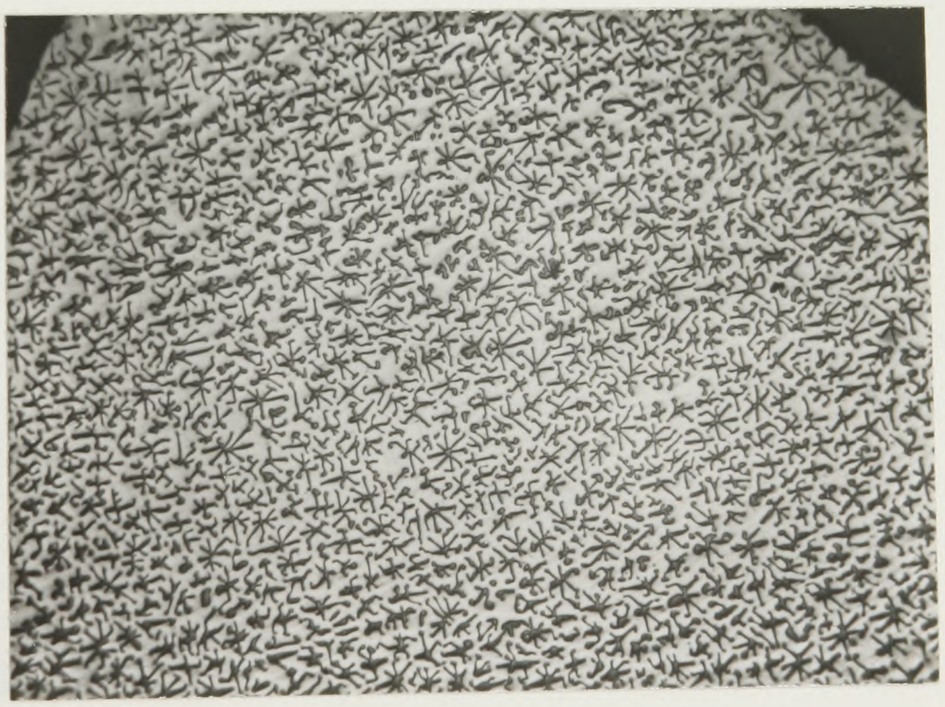


FIG. 58 Line Diagram of Angular Eutectic Growth Front showing the Relation of Projected Free Edge Distance (d) to the Silicon Morphology



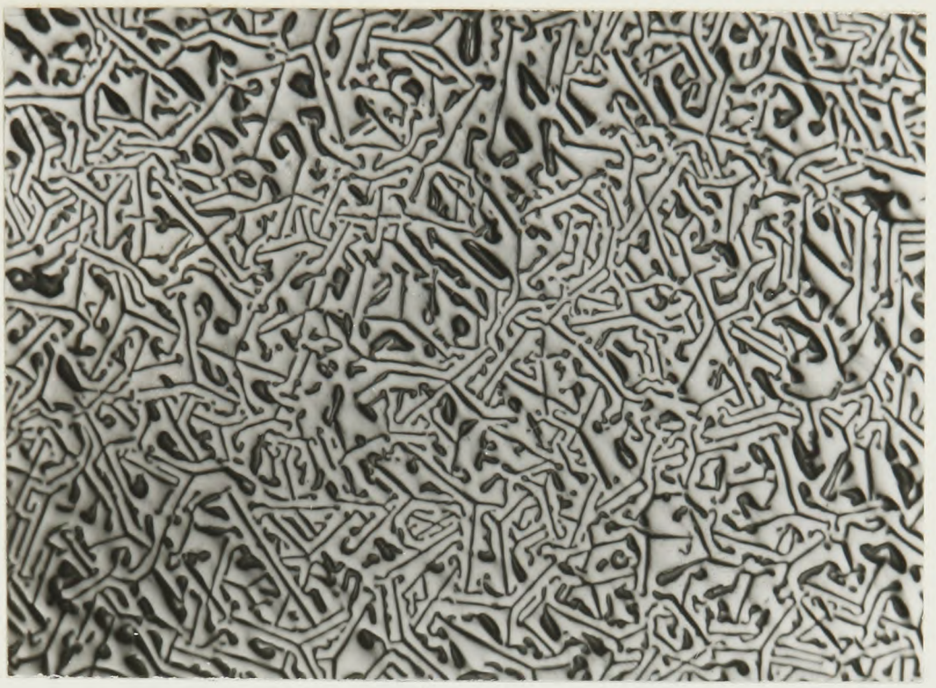
x 60

PLATE 59a Al/Si Eutectic - transverse section
($R = 2.78 \times 10^{-5}$ cm/sec., $G = 200^{\circ}C$/cm.)



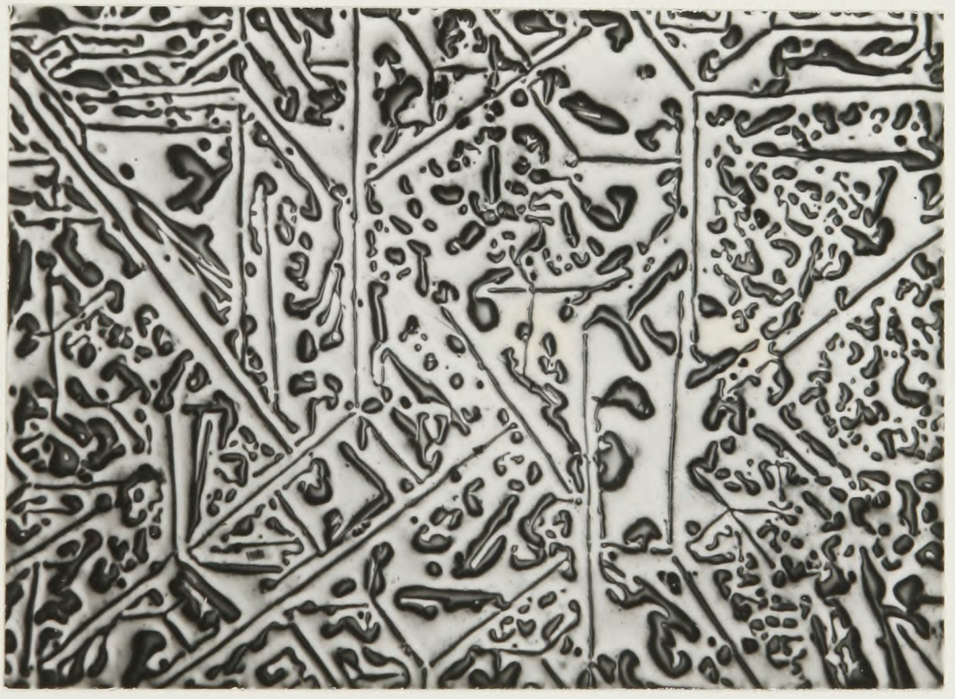
x 60

PLATE 59b Al/Si Eutectic - transverse section
($R = 2.78 \times 10^{-5}$ cm/sec., $G = 120^{\circ}C$/cm.)



x 60

PLATE 60a Al/Si Eutectic - transverse section
($R = 2.78 \times 10^{-5}$ cm/sec., $G = 29.5^{\circ}C$/cm.)



x 60

PLATE 60b Al/Si Eutectic - transverse section
($R = 2.78 \times 10^{-5}$ cm/sec., $G = 3.5^{\circ}C$/cm.)

G°C/cm	d (μ)	λ (μ)
120	20	50
75	32	62
45	55	85
29.5	83	100
16.0	150	160
3.5	420	300

TABLE 61 - showing the Variation of the Projected Free Edge Distance (d) and the Internodal Separation (λ) with Specimen Temperature Gradient (G) in Angular ($\langle 100 \rangle$ Si-type) Al/Si Eutectic Alloys.
(R was constant and equal to 2.78×10^{-5} cm/sec)

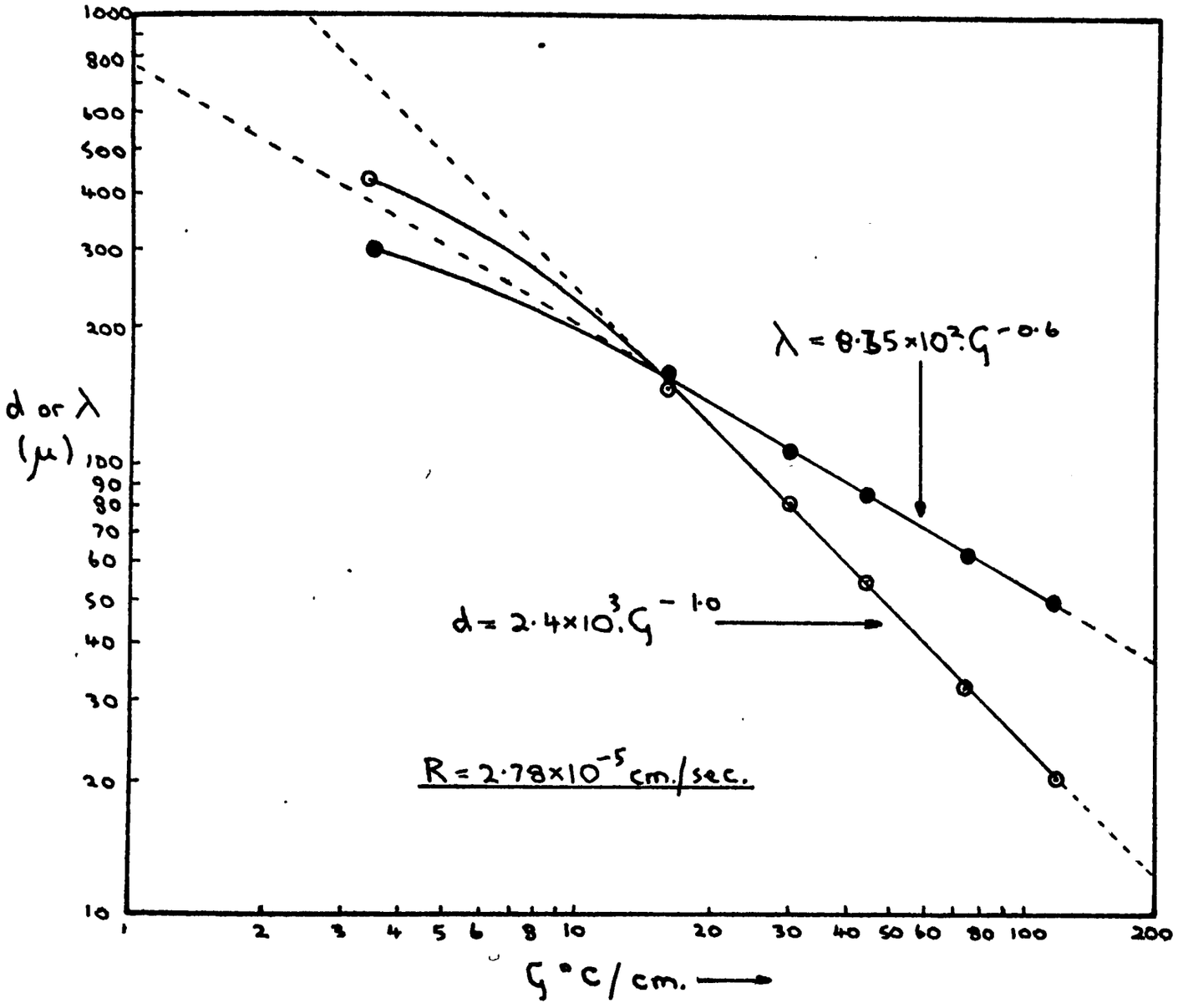
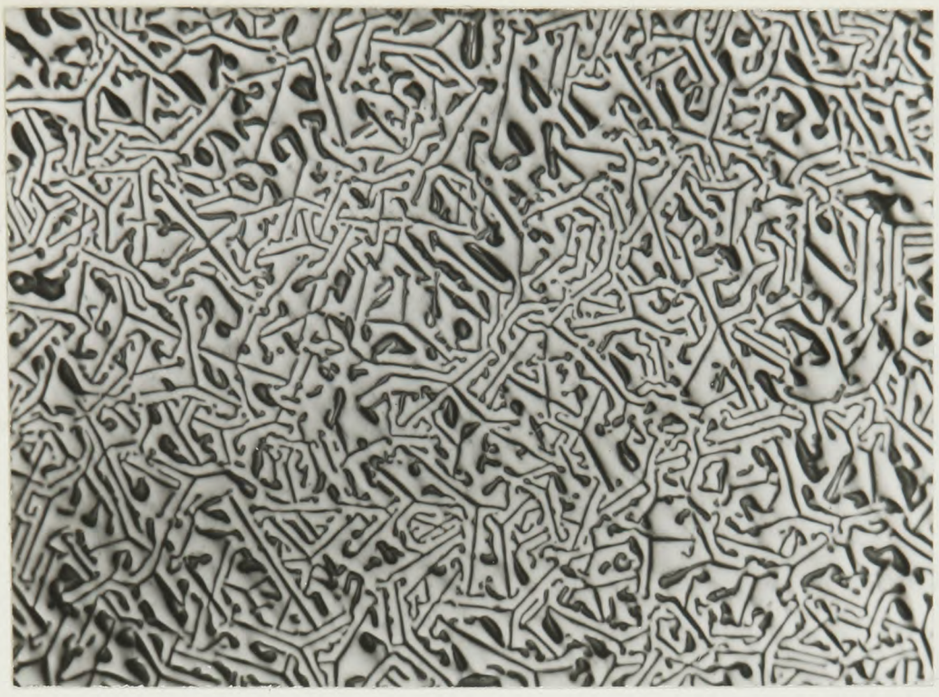
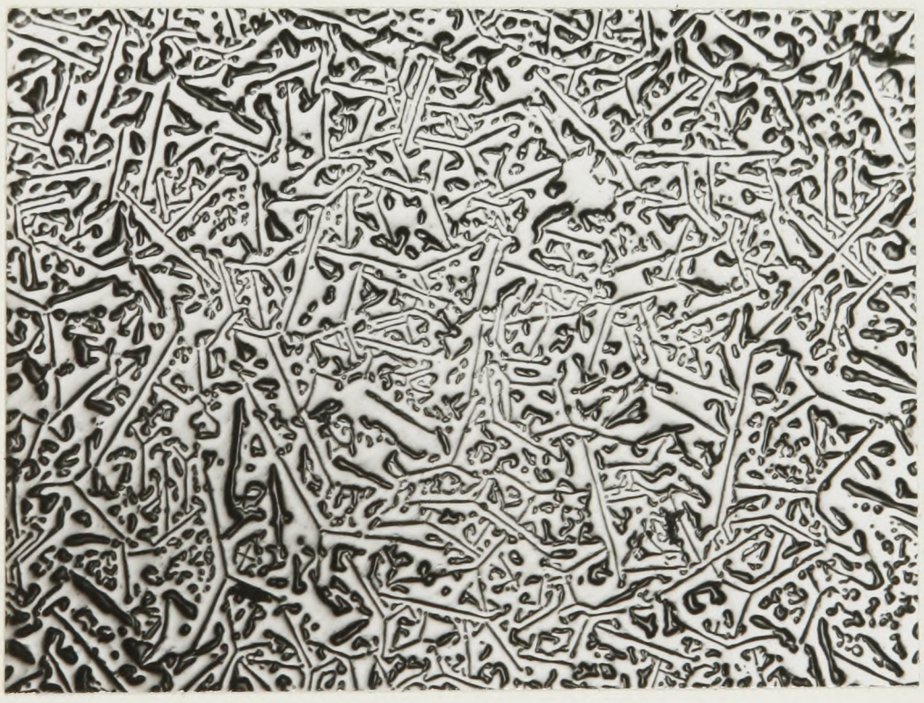


FIG. 62 A Graph showing the Dependence of the Projected Free Edge Distance (d) and the Internodal Separation (λ) on Specimen Temperature Gradient (G) in Angular (<100> Si-type) Al/Si Eutectic Alloys (see table 61)



x 60

PLATE 63a Al/Si Eutectic - transverse section
($R = 2.78 \times 10^{-5}$ cm/sec., $G = 29.5^{\circ}$C/cm.)

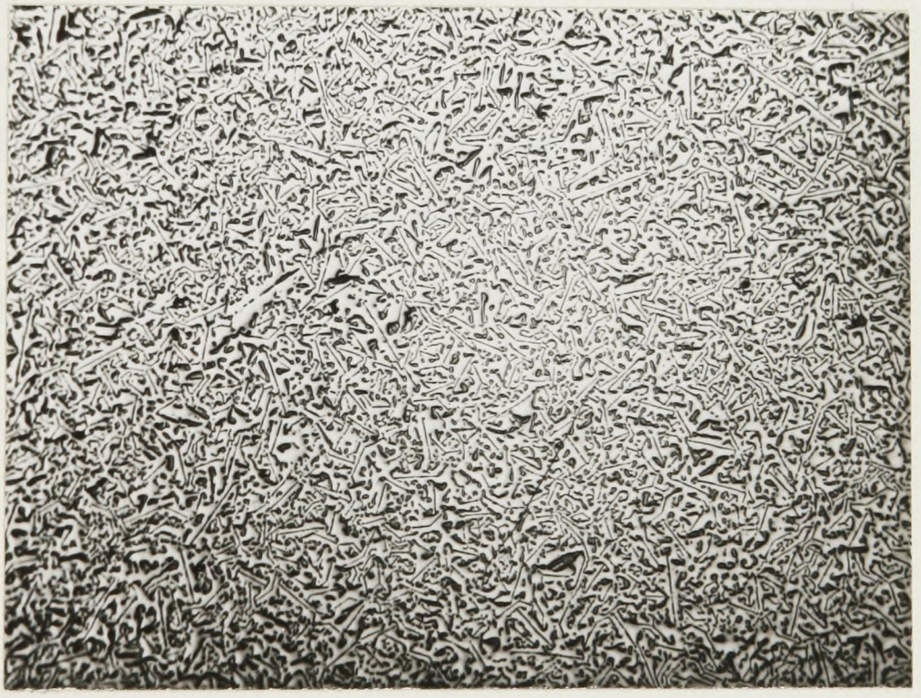


x 60

PLATE 63b Al/Si Eutectic - transverse section
($R = 6.48 \times 10^{-5}$ cm/sec., $G = 29.5^{\circ}$C/cm.)

x 60

PLATE 64a Al/Si Eutectic - transverse section
($R = 1.30 \times 10^{-4}$ cm/sec., $G = 29.5^{\circ}C$/cm.)



x 60

PLATE 64b Al/Si Eutectic - transverse section
($R = 2.5 \times 10^{-4}$ cm/sec., $G = 29.5^{\circ}C$/cm.)

R cm/sec	d (μ)	λ (μ)
2.78×10^{-5}	83	100
6.48×10^{-5}	80	98
1.30×10^{-4}	74	86
2.5×10^{-4}	46	62

TABLE 65 - showing the Variation of the Projected Free Edge Distance (d) and the Internodal Separation (λ) with Specimen Growth Rate (R) in Angular (<100> Si type) Al/Si Eutectic Alloys.

(G was constant and equal to 29.5°C/cm)

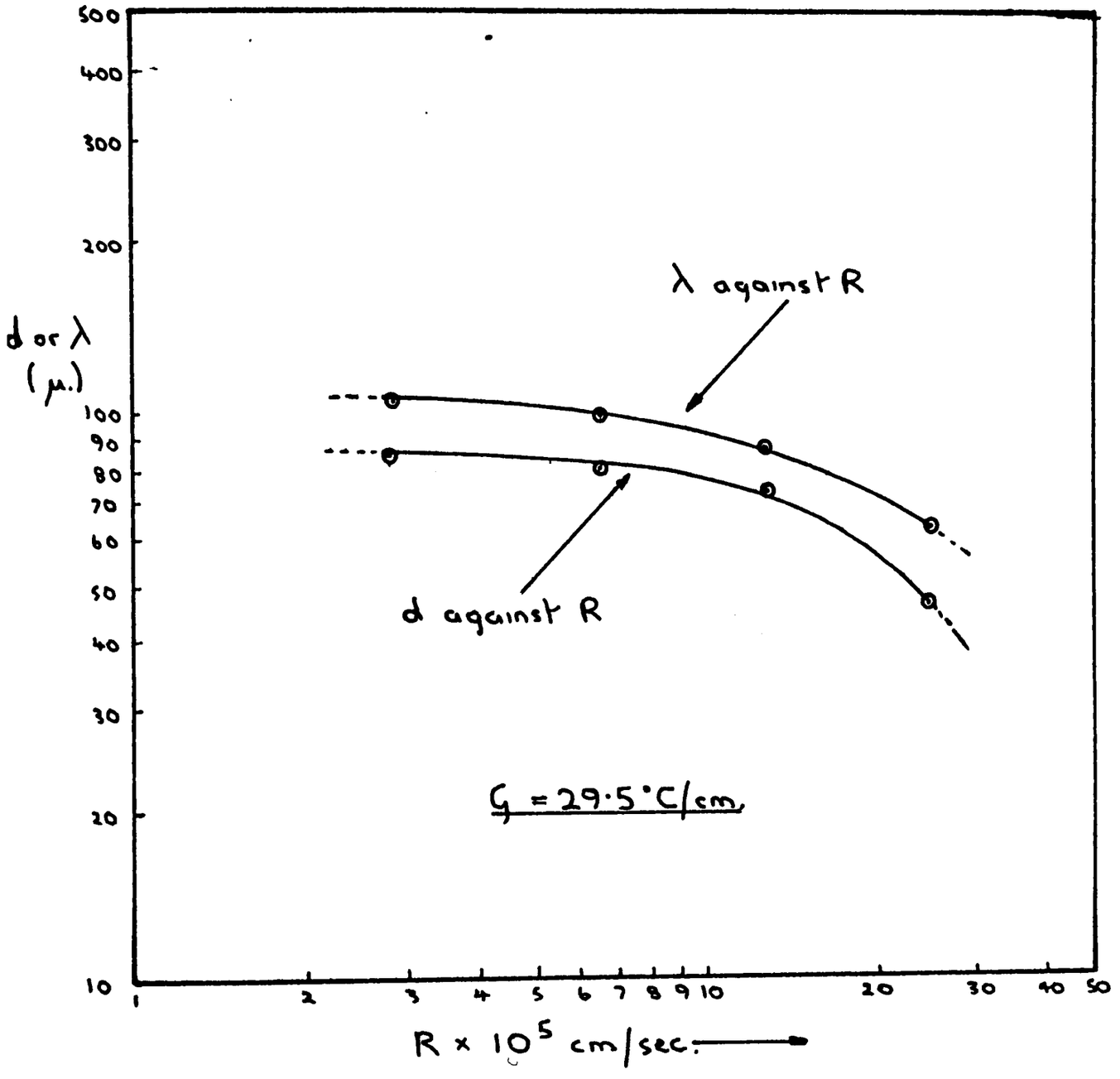
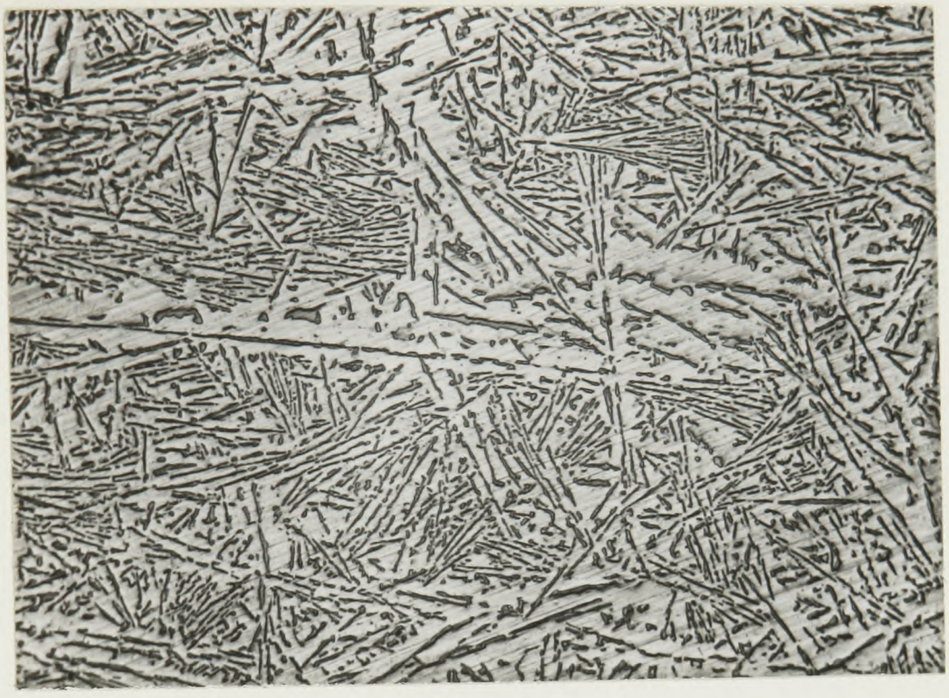


FIG. 66 A Graph showing the Dependence of the Projected Free Edge Distance (d) and the Internodal Separation (λ) on Specimen Growth Rate (R) in Angular (<100> Si-type) Al/Si Eutectic Alloys (see table 65)



x 60

PLATE 67a Al/Si Eutectic - longitudinal section ($R = 3.7 \times 10^{-4}$ cm/sec., $G = 16\ ^{o}C$/cm.)

PLATE 67b Al/Si Eutectic - Quenched Growth Front (after Chadwick, 1965 - growth conditions similar to Plate 67a)

x 60

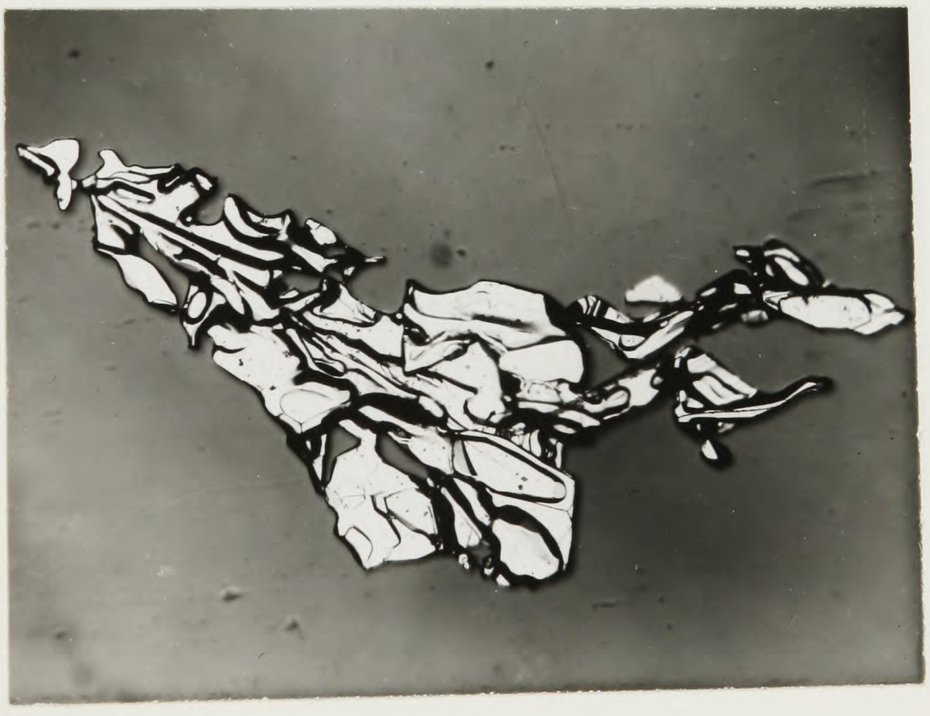
PLATE 60a Extracted Fibrous and Platelike Irregular Silicon
($R = 3.7 \times 10^{-4}$ cm/sec., $G = 16.0^{\circ}C$/cm.)

x 60

PLATE 68b Extracted Fibrous and Platelike Irregular Silicon
($R = 3.7 \times 10^{-4}$ cm/sec., $G = 16.0^{\circ}C$/cm.)

x 125

PLATE 69a An extracted Idiomorphic Silicon Plate
($R = 3.7 \times 10^{-4}$ cm/sec., $G = 16^{\circ}C$/cm.)



x 125

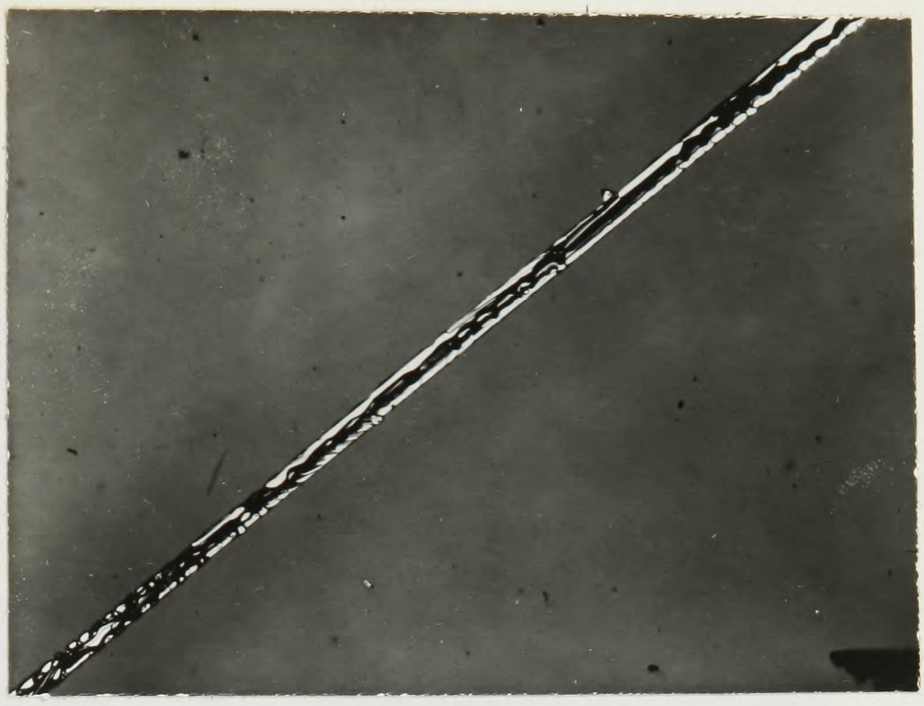
PLATE 69b An Extracted Idiomorphic Silicon Plate
($R = 3.7 \times 10^{-4}$ cm/sec., $G = 16^{\circ}C$/cm.)

x 125

PLATE 70a An Extracted Triangular Silicon Plate
(see fig. 74a)
($R = 3.7 \times 10^{-4}$ cm/sec., $G = 16^{\circ}C$/cm.)

x 125

PLATE 70b An Extracted Triangular Silicon Plate
(see fig. 74a)
($R = 3.7 \times 10^{-4}$ cm/sec., $G = 16^{\circ}C$/cm.)



x 60

PLATE 71a An Extracted Silicon Lath (see fig.74b)
(R = 3.7 x 10^{-4}cm/sec., G = 16°C/cm.)

x 125

PLATE 71b An Extracted Silicon Lath (see fig.74b)
(R = 3.7 x 10^{-4}cm/sec., G = 16°C/cm.)

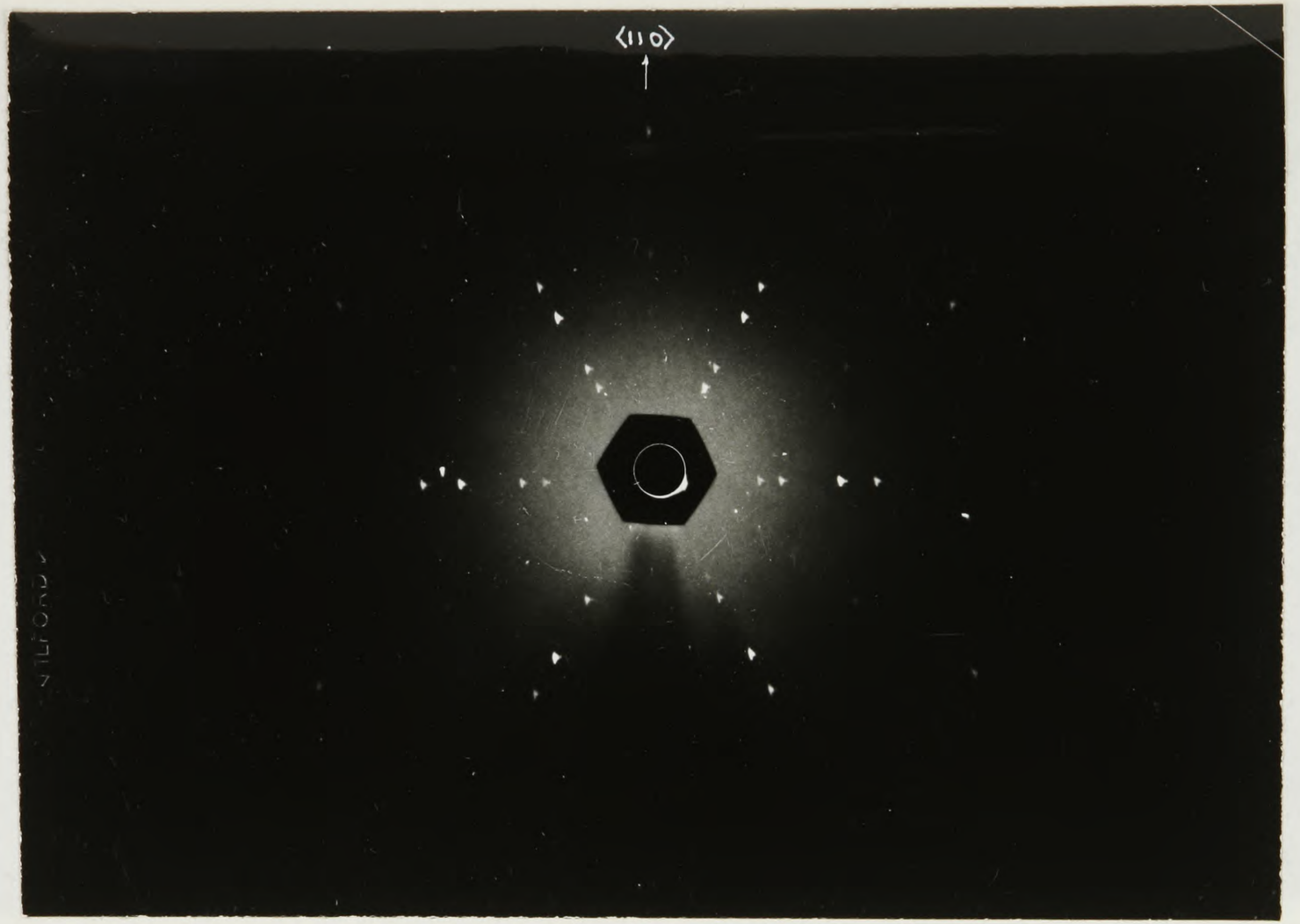


PLATE 72 X-Ray Laue Photograph taken normal to an extracted {111} Irregular particle containing a {111} Spinel Twin

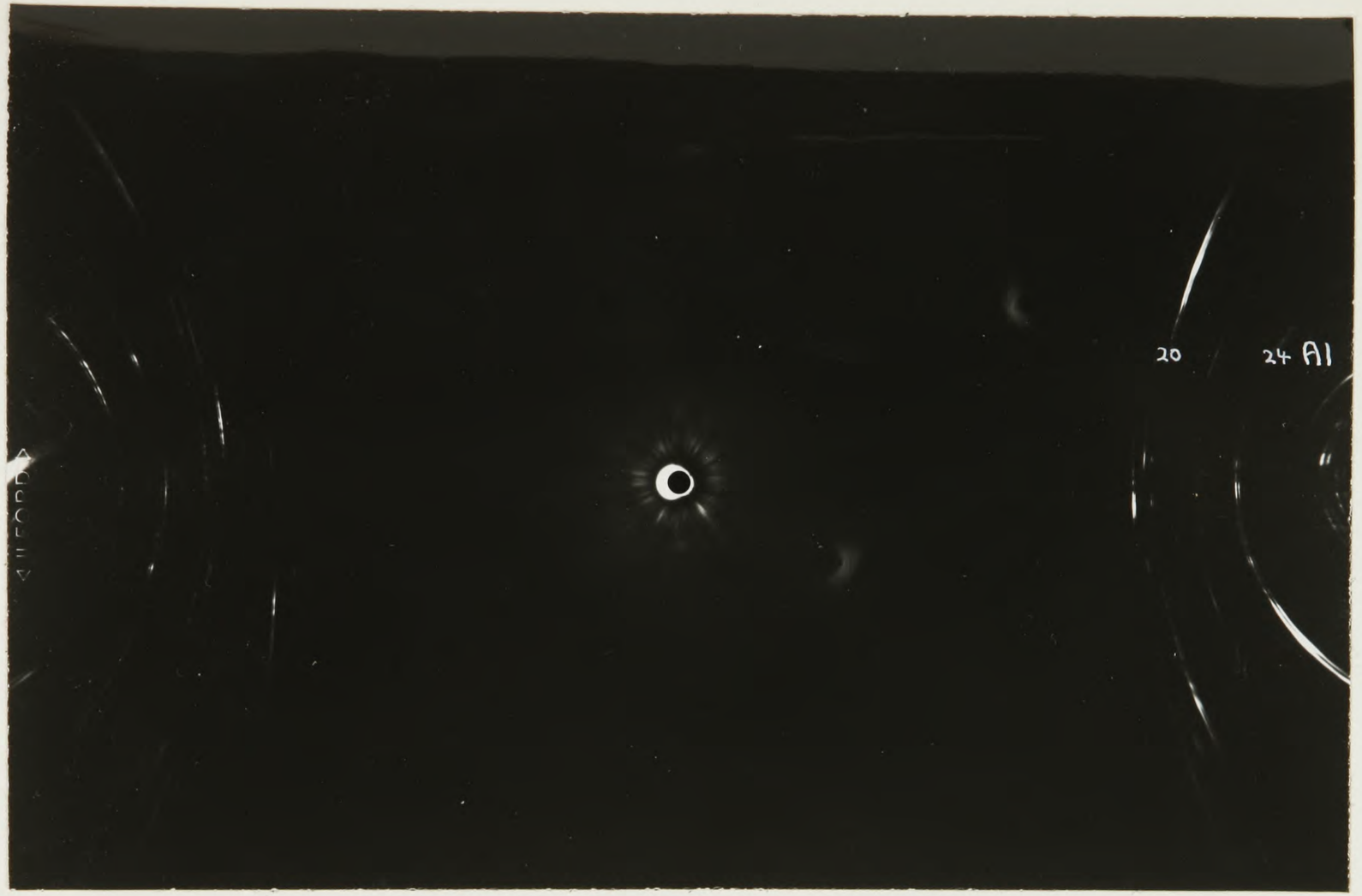


PLATE 73 A Back Reflection Oscillation Photograph (Cu K α K β) about the Growth Direction of a Silicon Lath Crystal in Al/Si Eutectic Alloy

(R = 3.7 x 10^{-4}cm/sec., G = 16.0^{o}C/cm.)

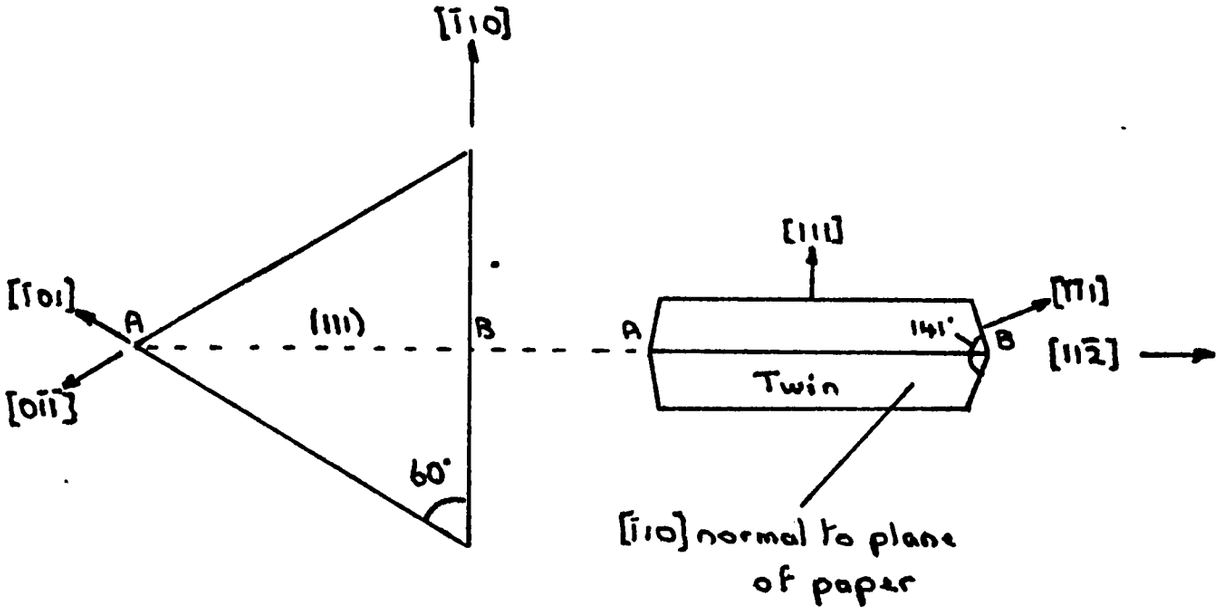


FIG. 74a Triangular Silicon Plate

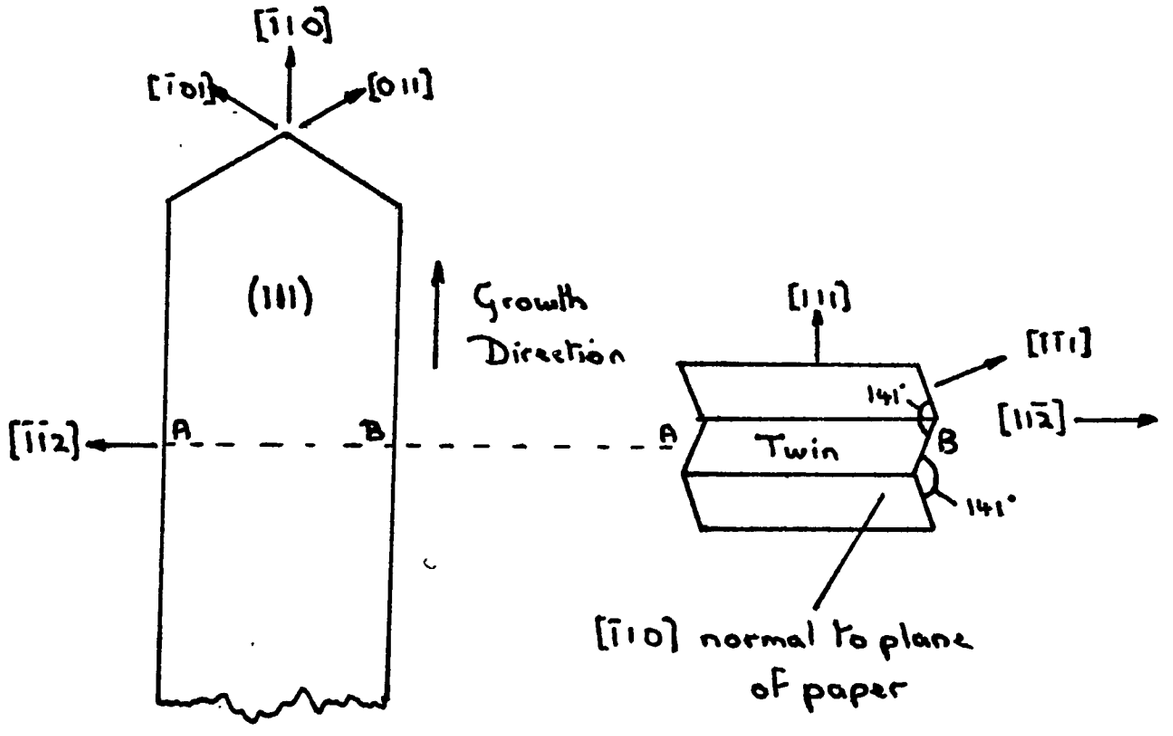
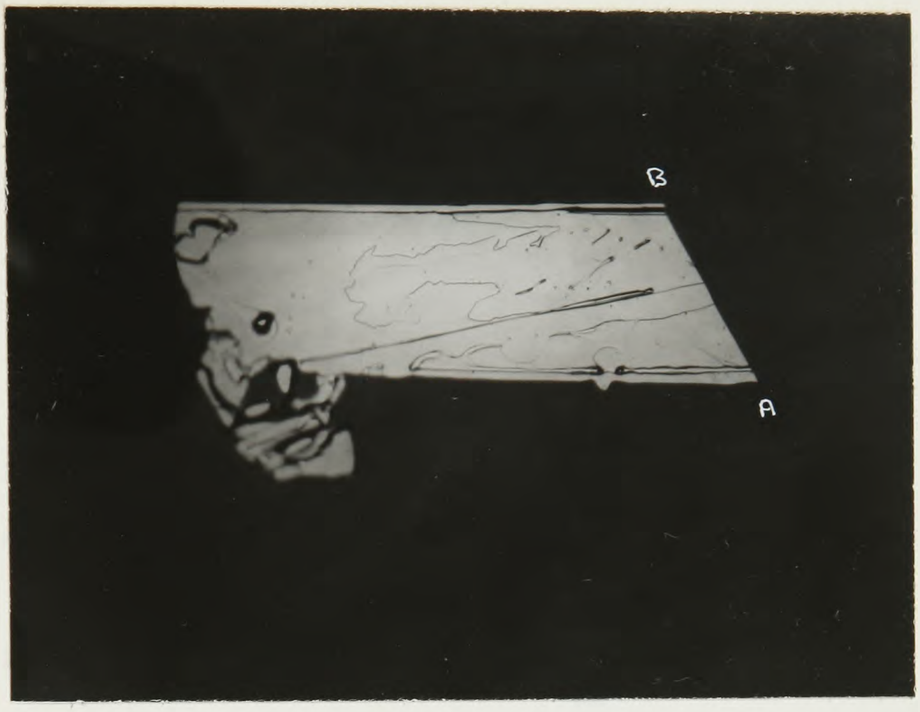
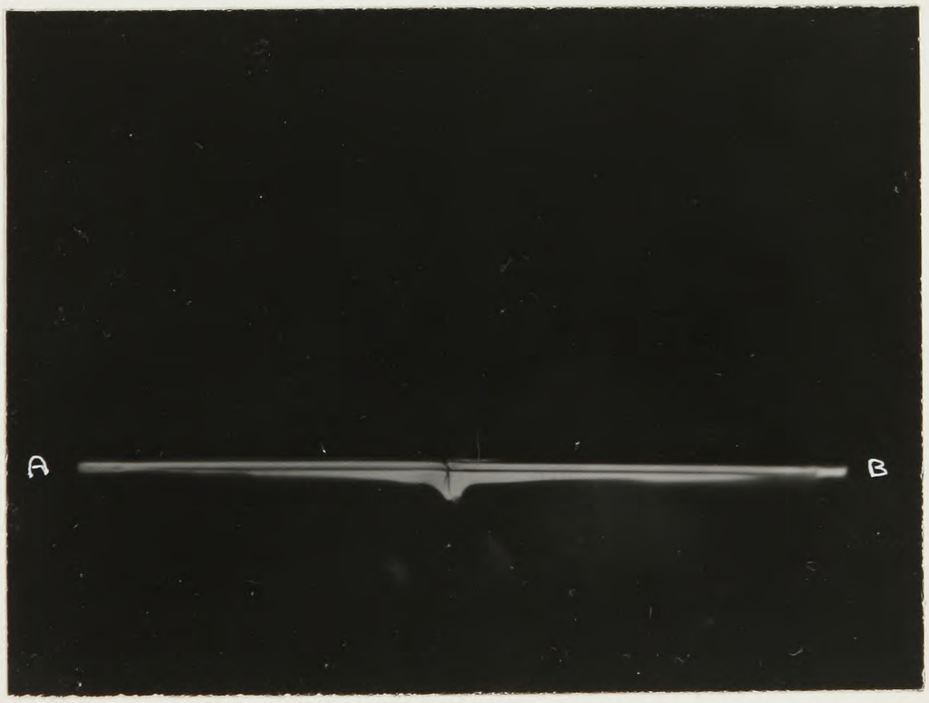


FIG. 74b Lath-shaped Silicon Plate



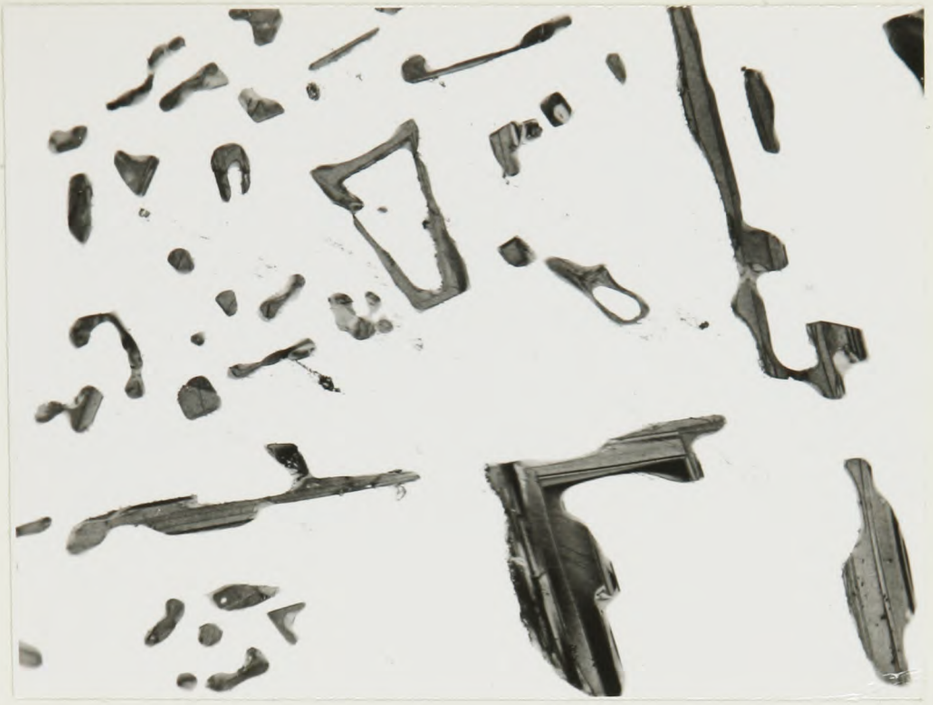
x 125

PLATE 75a Side View of Fractured Silicon Lath
($R = 3.7 \times 10^{-4}$ cm/sec., $G = 16^{\circ}C$/cm.)



x 460

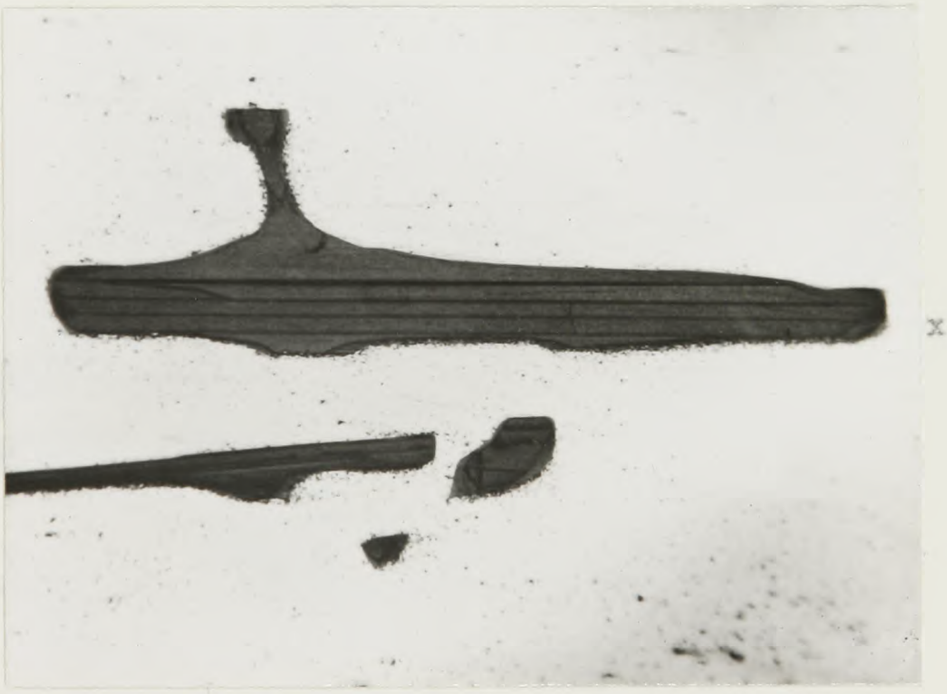
PLATE 75b Silicon Lath Fractograph
($R = 3.7 \times 10^{-4}$ cm/sec., $G = 16^{\circ}C$ /cm.)



x 225

PLATE 76a C.P.4 Etched Al/Si Eutectic - longitudinal section

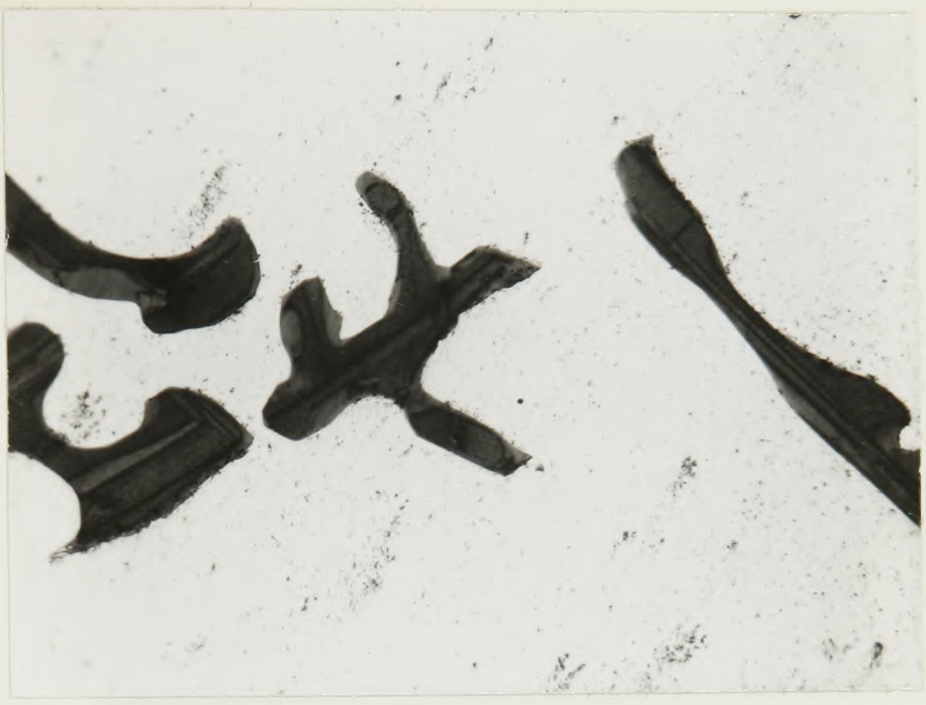
($R = 3.7 \times 10^{-4}$ cm/sec., $G = 3.5^{\circ}$C/cm.)



x 460

PLATE 76b C.P.4 Etched Al/Si Eutectic - longitudinal section

($R = 3.7 \times 10^{-4}$ cm/sec., $G = 3.5^{\circ}$C/cm.)



x 460

PLATE 77a C.P.4 Etched Al/Si Eutectic - longitudinal section

($R = 3.7 \times 10^{-4}$ cm/sec., $G = 3.5^{\circ}$C/cm)

x 460

PLATE 77b C.P.4 Etched Al/Si Eutectic - longitudinal section

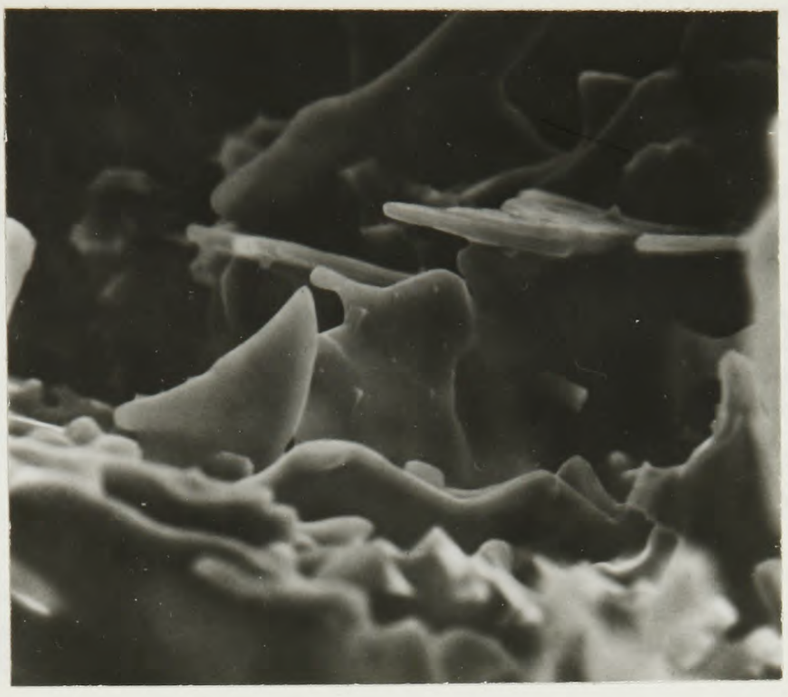
($R = 3.7 \times 10^{-4}$ cm/sec., $G = 3.5^{\circ}$C/cm.)

x 750

PLATE 78a Heavily Etched Al/Si Eutectic - growth direction 45° to normal of paper
($R = 3.7 \times 10^{-4}$ cm/sec., $G = 16^{\circ}C$/cm.)

x 1500

PLATE 78b Heavily Etched Al/Si Eutectic - growth direction 45° to normal of paper
($R = 3.7 \times 10^{-4}$ cm/sec., $G = 16^{\circ}C$/cm.)

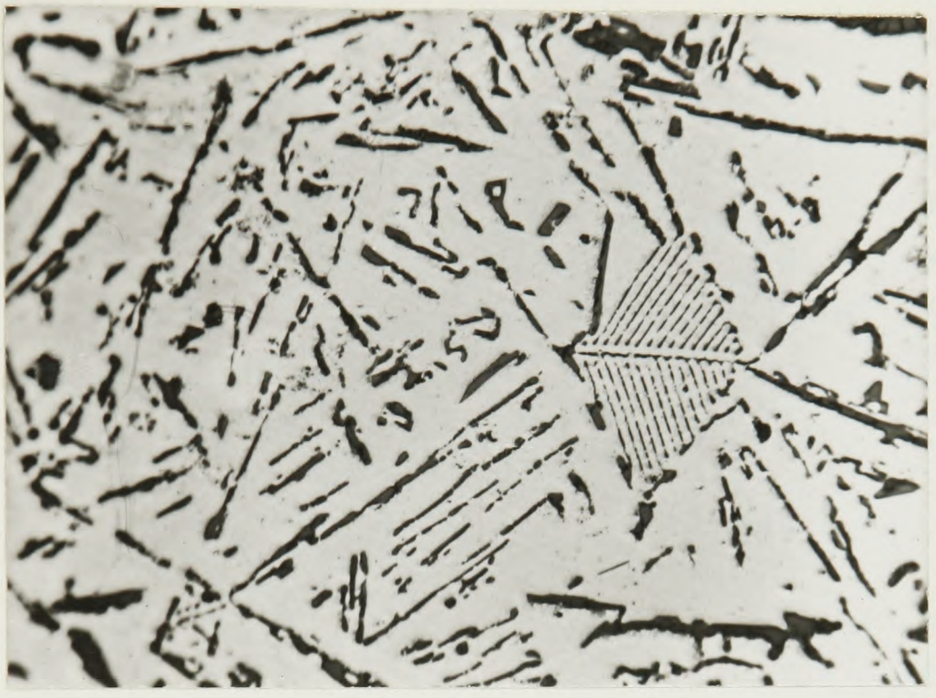


x 1500

PLATE 79a Heavily Etched Al/Si Eutectic - growth direction 60° to normal of paper
($R = 3.7 \times 10^{-4}$ cm/sec., $G = 16^{\circ}C$/cm.)

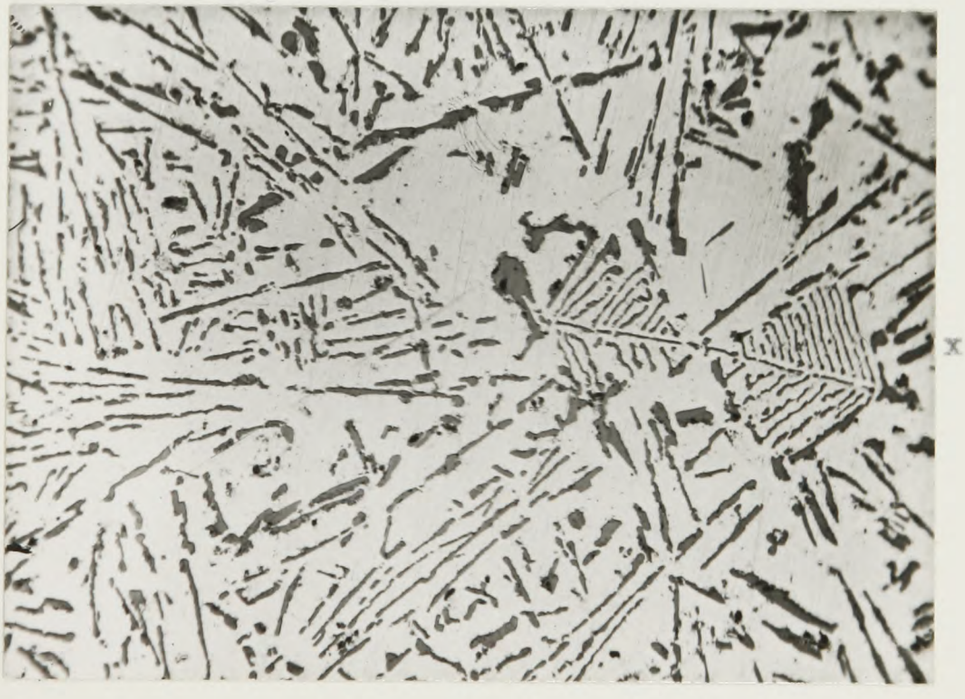
x 1500

PLATE 79b Heavily Etched Al/Si Eutectic - growth direction $22\frac{1}{2}^{\circ}$ to normal of paper
($R = 3.7 \times 10^{-4}$ cm/sec., $G = 16^{\circ}C$/cm.)



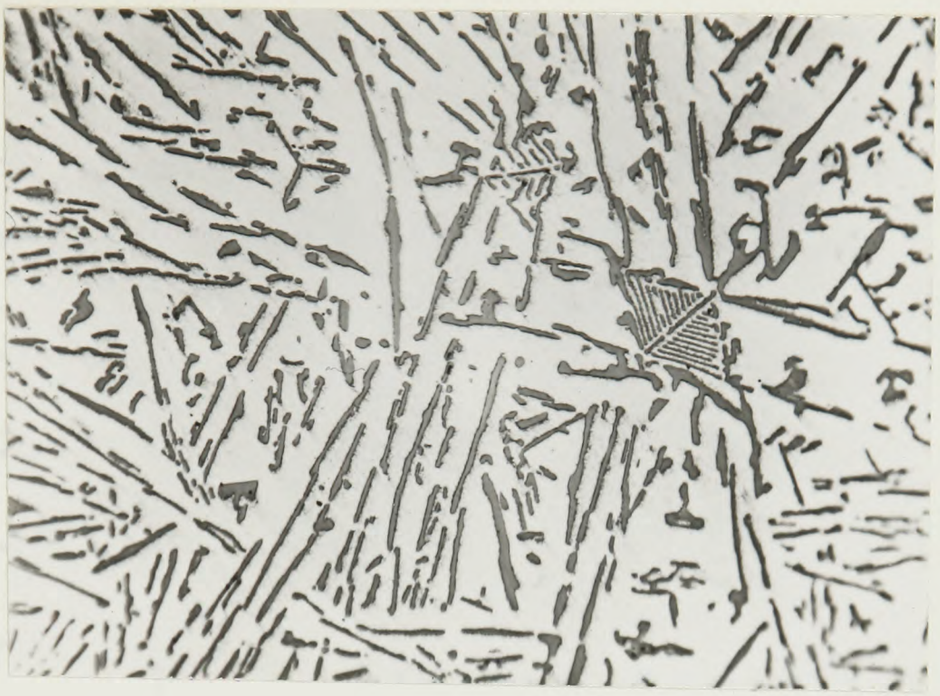
x 225

PLATE 80a Al/Si Eutectic - transverse section
($R = 3.7 \times 10^{-4}$ cm/sec., $G = 29.5^{\circ}C$/cm.)



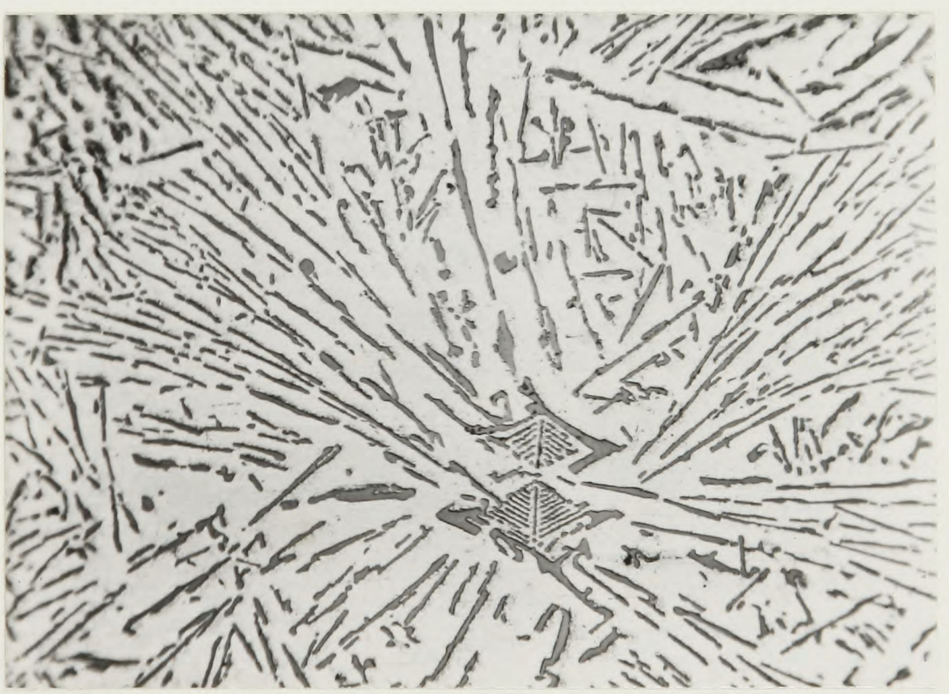
x 225

PLATE80b Al/Si Eutectic - transverse section
($R = 6.3 \times 10^{-4}$ cm/sec., $G = 29.5^{\circ}C$/cm.)



x 225

PLATE 81a Al/Si Eutectic - transverse section
($R = 7.41 \times 10^{-4}$ cm/sec., $G = 29.5^{\circ}C$/cm.)



x 225

PLATE 81b Al/Si Eutectic - transverse section
($R = 1.37 \times 10^{-3}$ cm/sec., $G = 29.5^{\circ}C$/cm.)

R cm/sec	λ irregular (μ)	λ webs (μ)
3.70×10^{-4}	11.54	4.31
5.0×10^{-4}	9.92	3.77
6.3×10^{-4}	8.63	3.38
7.41×10^{-4}	7.69	3.15
1.37×10^{-3}	5.77	2.46

TABLE 82 - showing the Variation of the Interparticle Spacing (λ) with Specimen Growth Rate (R) for both Irregular and Complex Regular Al/Si Eutectic Alloys.

(G was constant and equal to 29.5°C/cm)

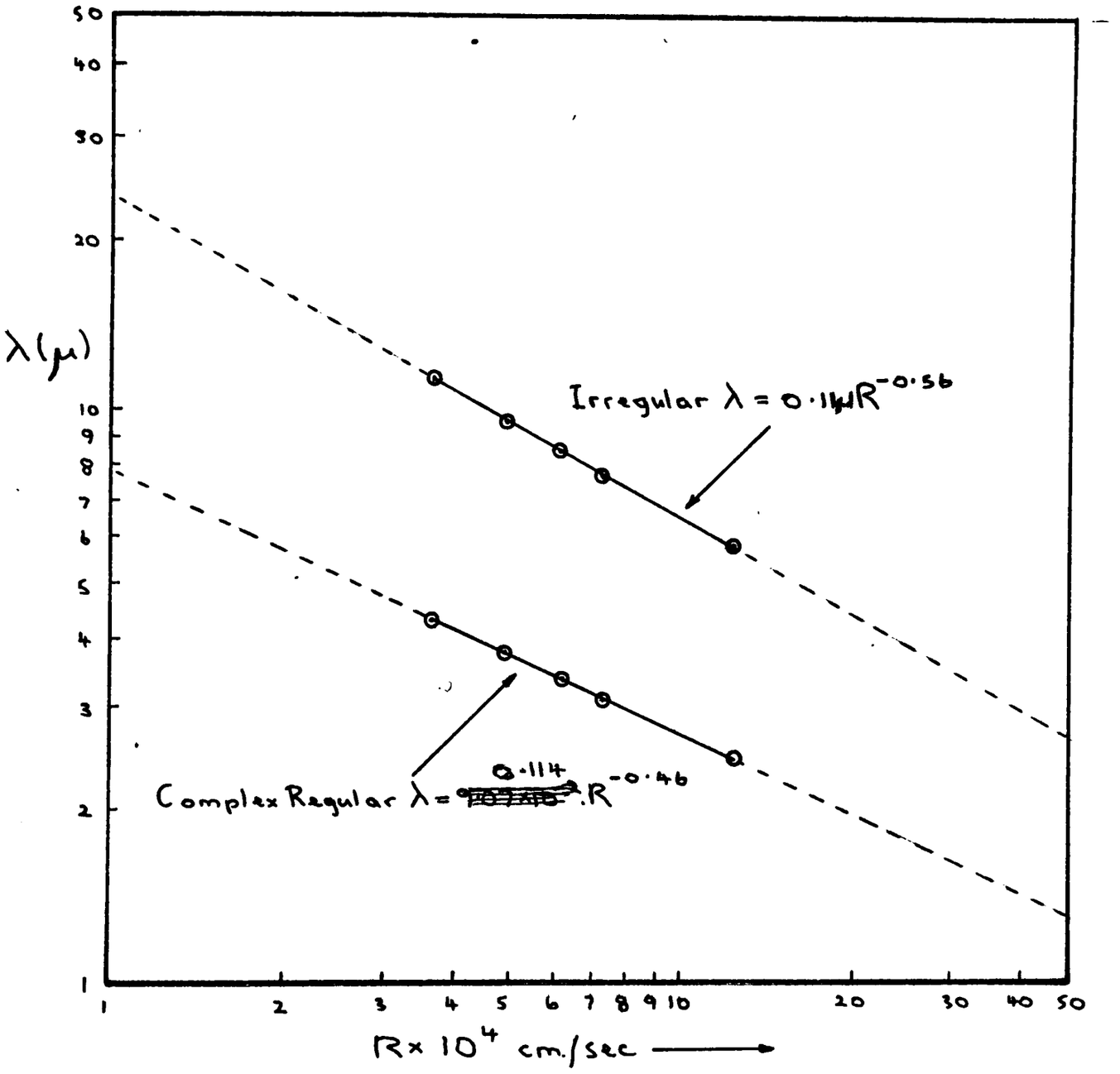
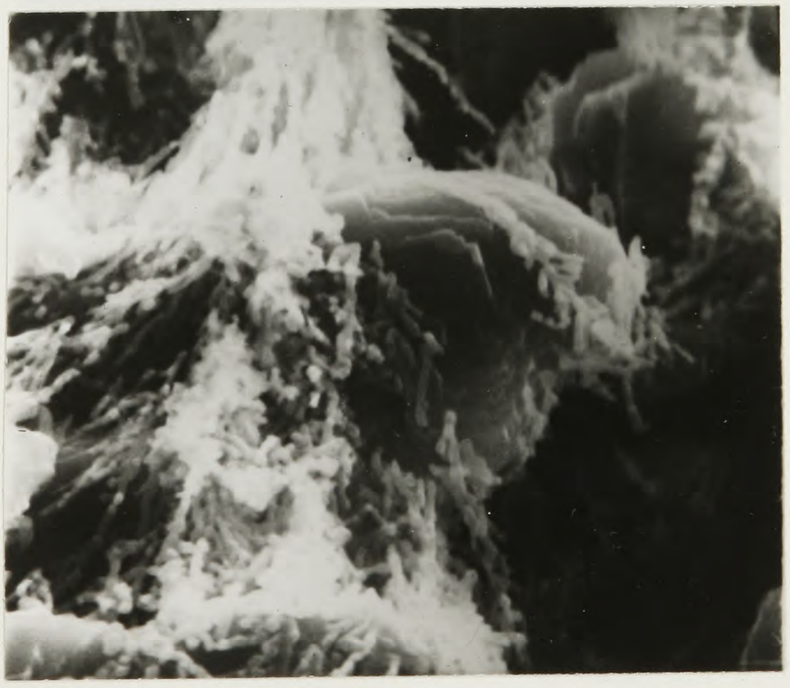


FIG. 83 A Graph showing the Dependence of the Interparticle Spacing (λ) on the Specimen Growth Rate (R) for both Irregular and Complex Regular Al/Si Eutectic Alloys (see table 82)

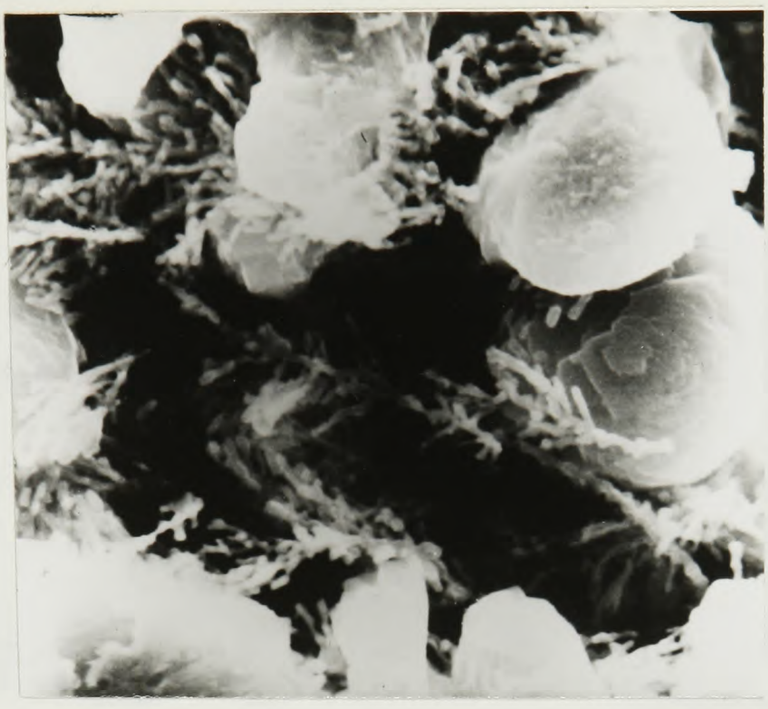
x 460

PLATE 84a Rapidly Quenched Al/Si Eutectic



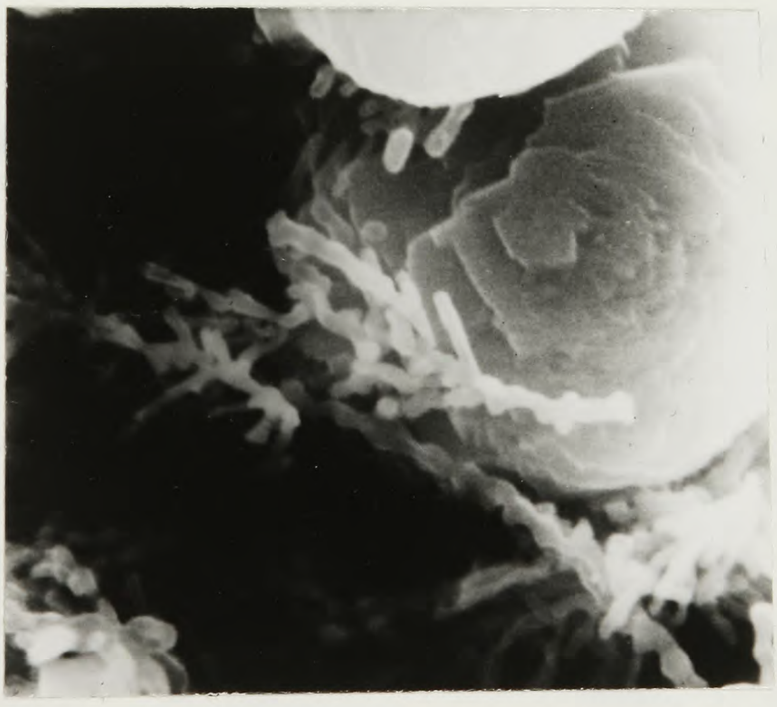
x 7,500

PLATE 84b Heavily Etched Rapidly Quenched Al/Si Eutectic



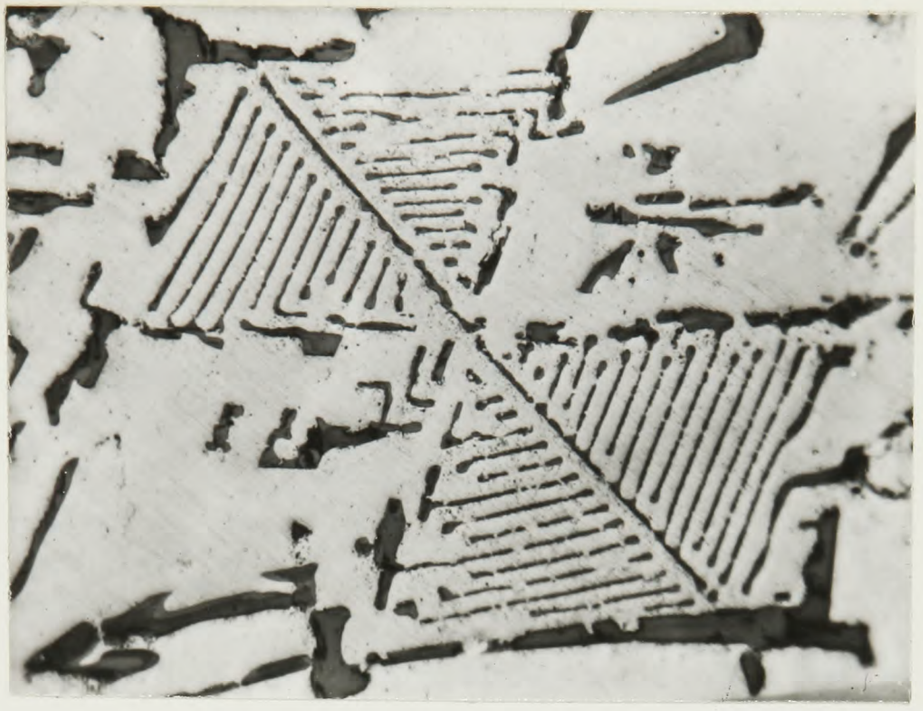
x 7,500

PLATE 85a Heavily Etched Rapidly Quenched Al/Si Eutectic



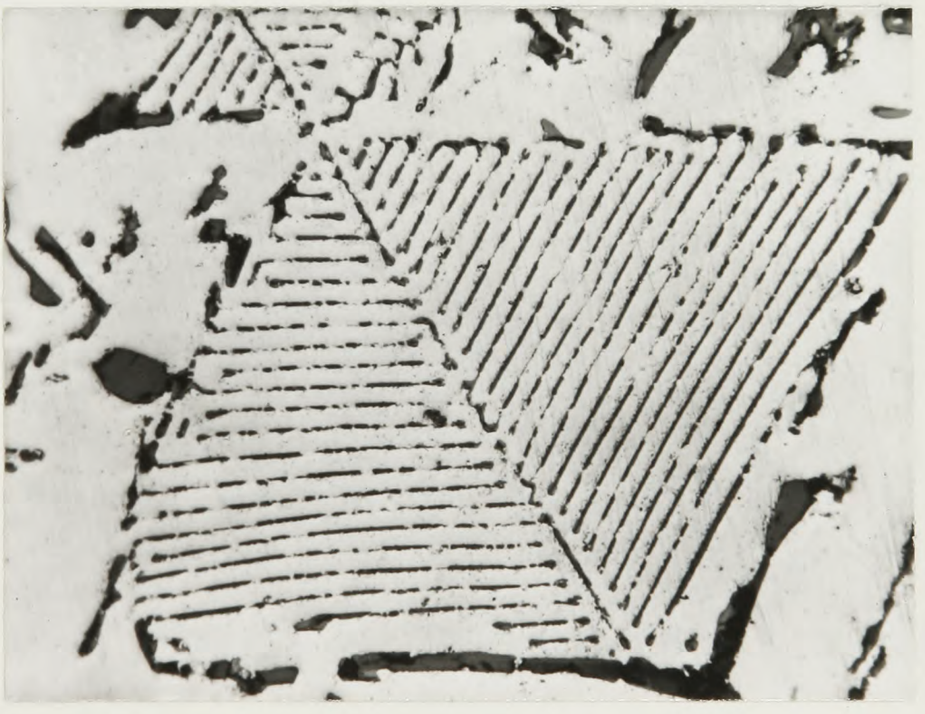
x 15,000

PLATE 85b Heavily Etched Rapidly Quenched Al/Si Eutectic



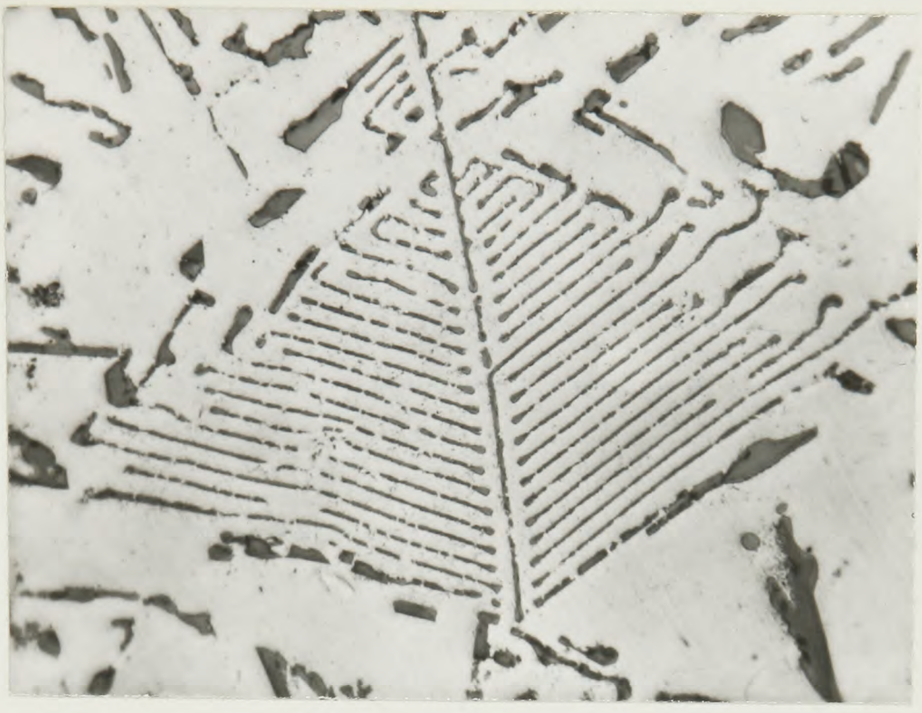
x 460

PLATE 86a Al/Si Eutectic - transverse section
(R = 3.7 x 10^{-4}cm/sec., G = 29.5°C/cm.)



x 460

PLATE 86b Al/Si Eutectic - transverse section
(R = 3.7 x 10^{-4}cm/sec., G = 29.5°C/cm.)



x 460

PLATE 87a Al/Si Eutectic - transverse section
($R = 3.7 \times 10^{-4}$ cm/sec., $G = 29.5^{\circ}C$/cm.)

x 460

PLATE 87b Al/Si Eutectic - transverse section
($R = 3.7 \times 10^{-4}$ cm/sec., $G = 29.5^{\circ}C$/cm.)

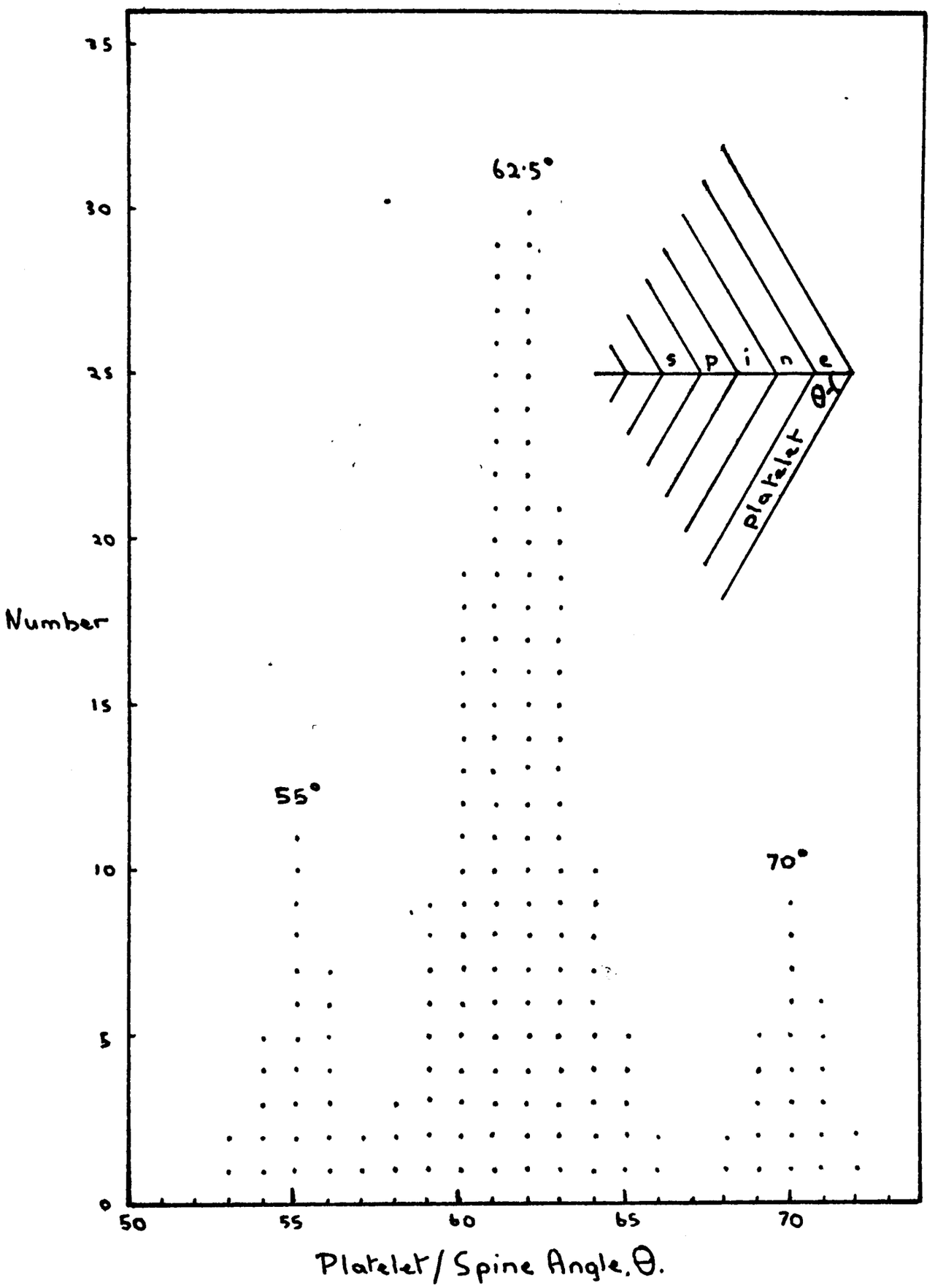
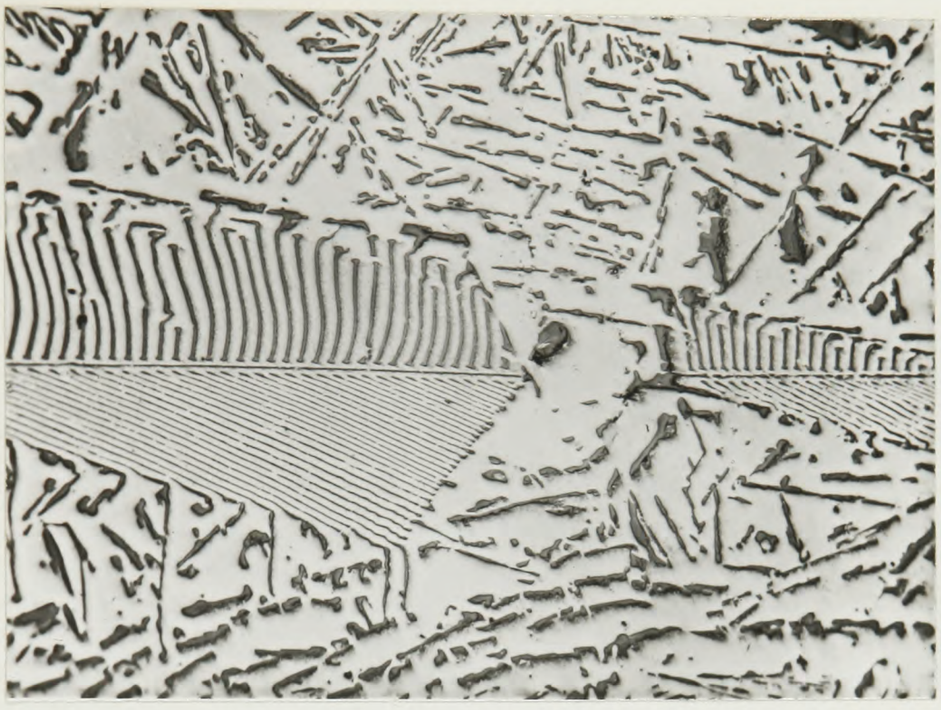
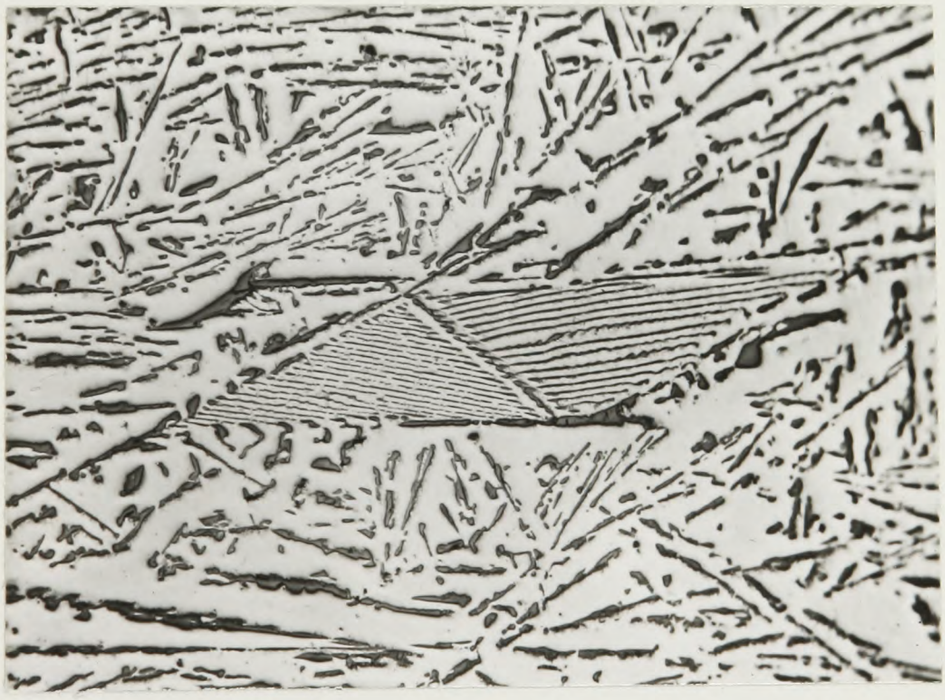


FIG. 88 Complex Regular Silicon Particles - Platelet/Spine Angle Histogram



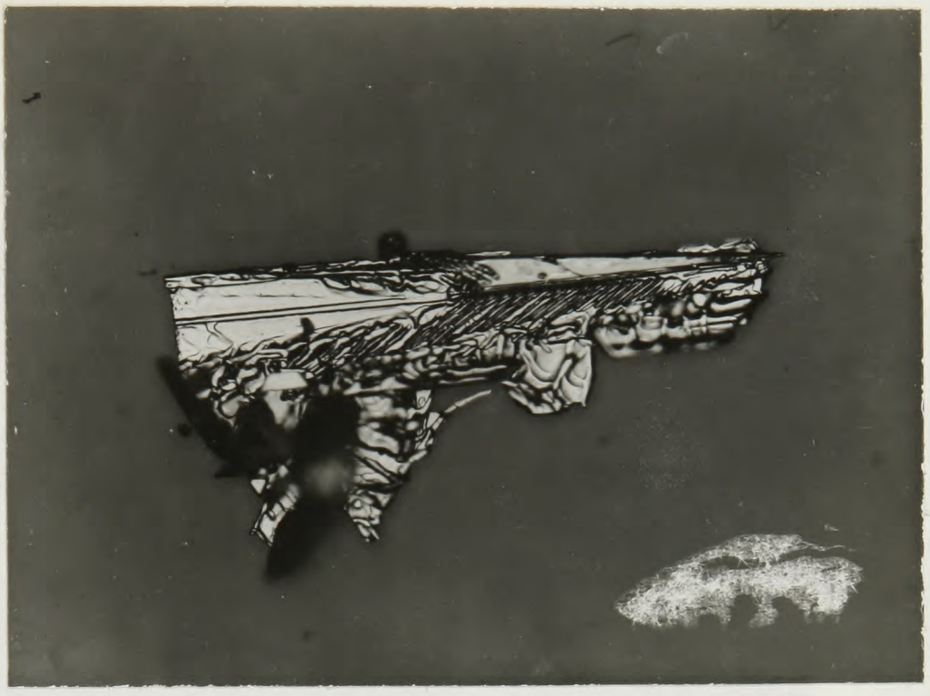
x 125

PLATE 89a Al/Si Eutectic - longitudinal section
(R = 3.7 x 10^{-4}cm/sec., G = 29.5^{o}C/cm.)



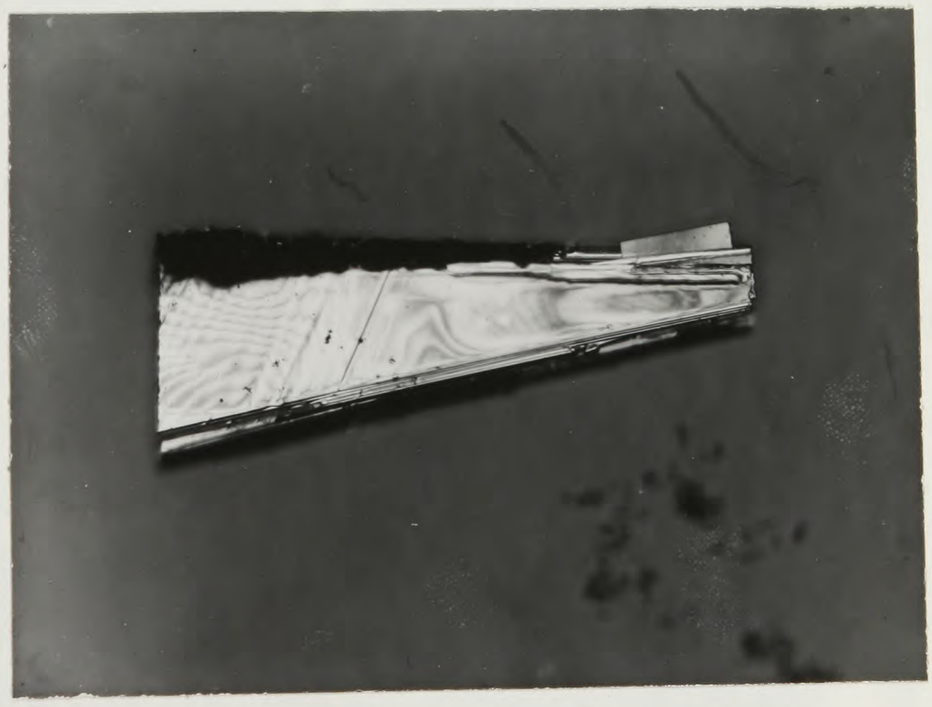
x 125

PLATE 89b Al/Si Eutectic - longitudinal section
(R = 3.7 x 10^{-4}cm/sec., G = 29.5^{o}C/cm.)



x 125

PLATE 90a Extracted Complex Regular Si Particle
($R = 3.7 \times 10^{-4}$ cm/sec., $G = 29.5^{\circ}$C/cm.)



x 125

PLATE 90b Extracted Complex Regular Si Platelets
($R = 3.7 \times 10^{-4}$ cm/sec., $G = 29.5^{\circ}$C/cm.)

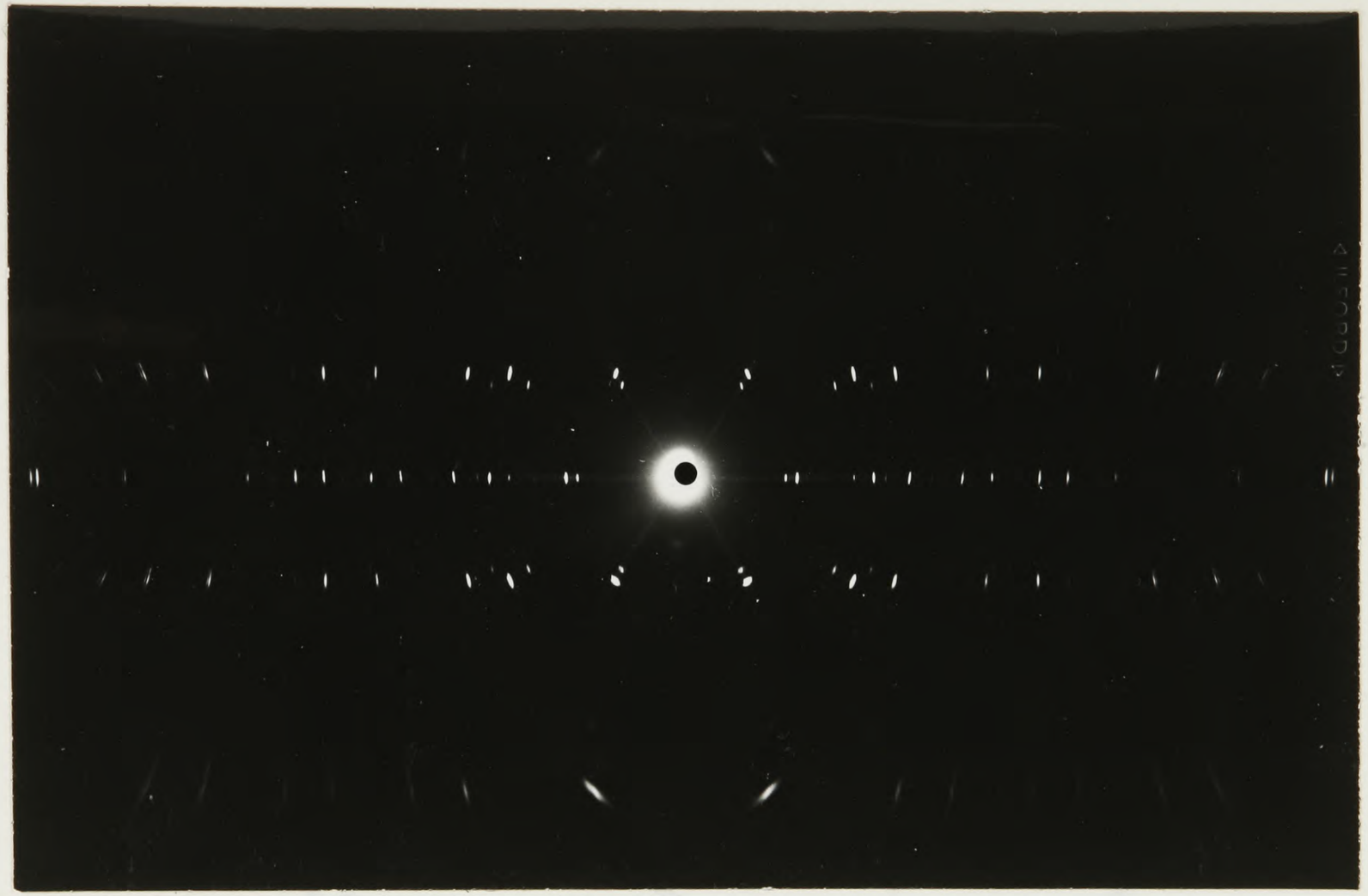


PLATE 91 X-Ray Rotation Photograph (Cu Kα Kβ radiation) showing the <110> preferred growth direction of an Extracted Complex Regular Silicon Particle

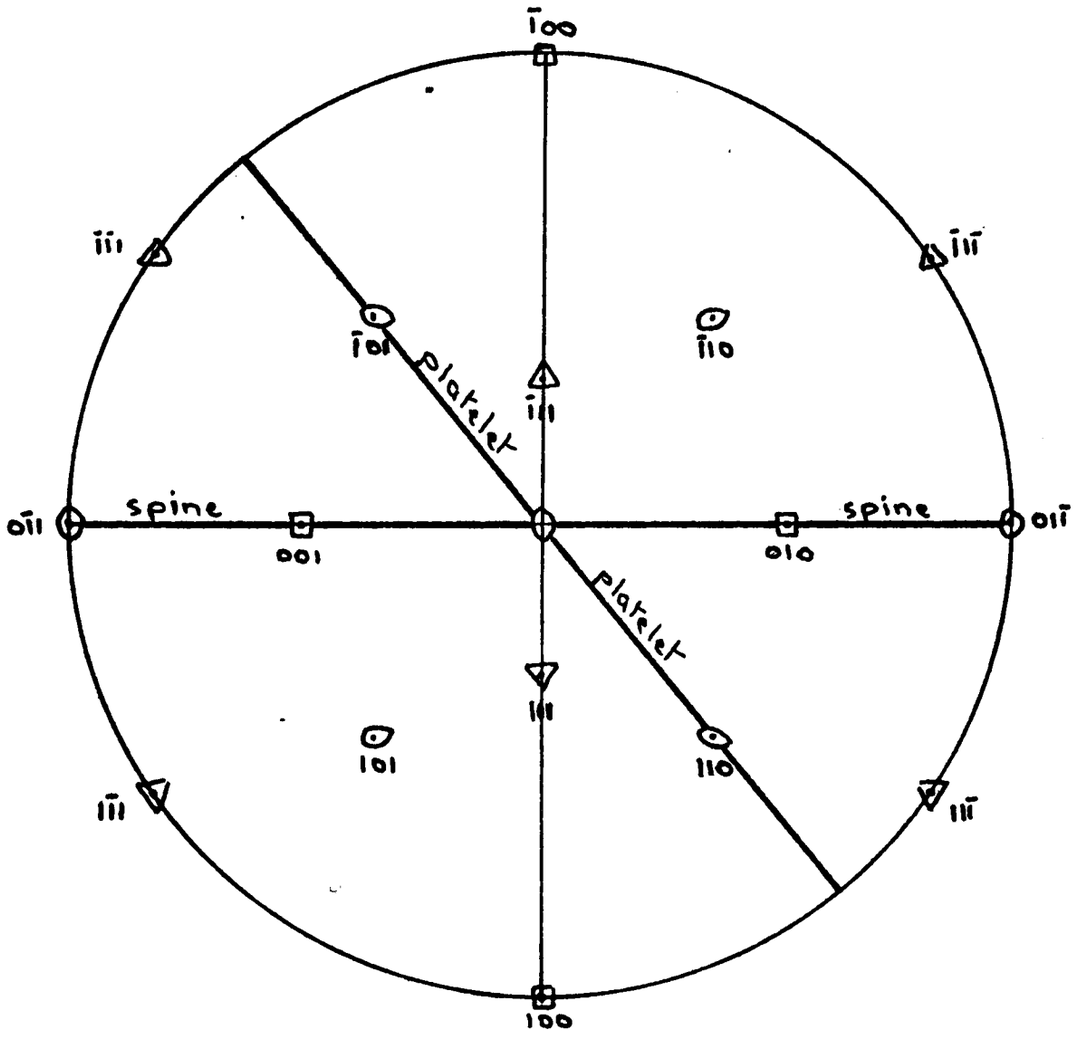


FIG. 92 [011] Stereographic Projection showing the Spine/Platelet Relationship of a Simple Web (see fig. 93a)

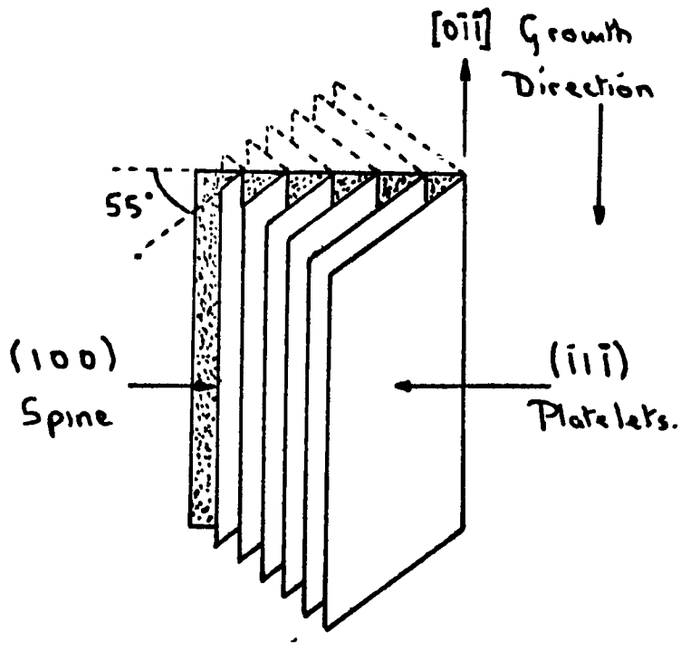
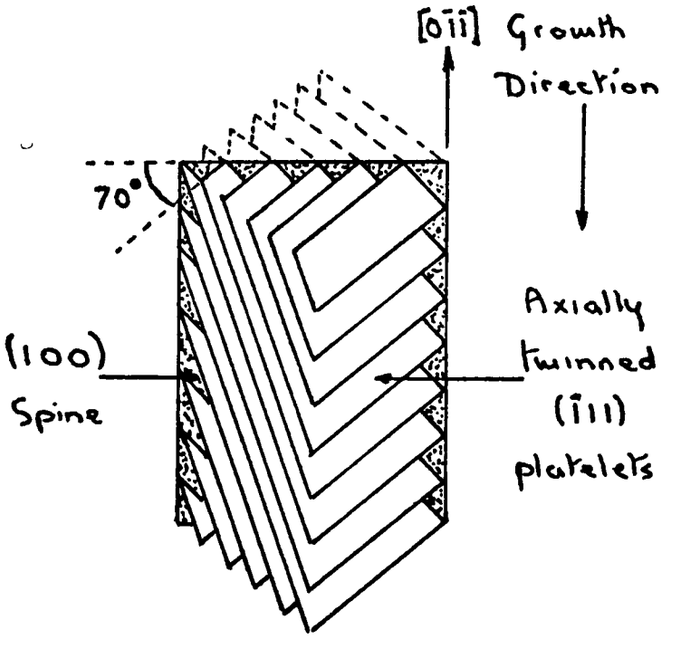


FIG. 93a A Simple Web (see fig. 92)



Angle between axially twinned [1ī1] and [0ī1] = 35°

FIG. 93b A 1st Order {111} Spinel Twinned Web (see fig. 94)

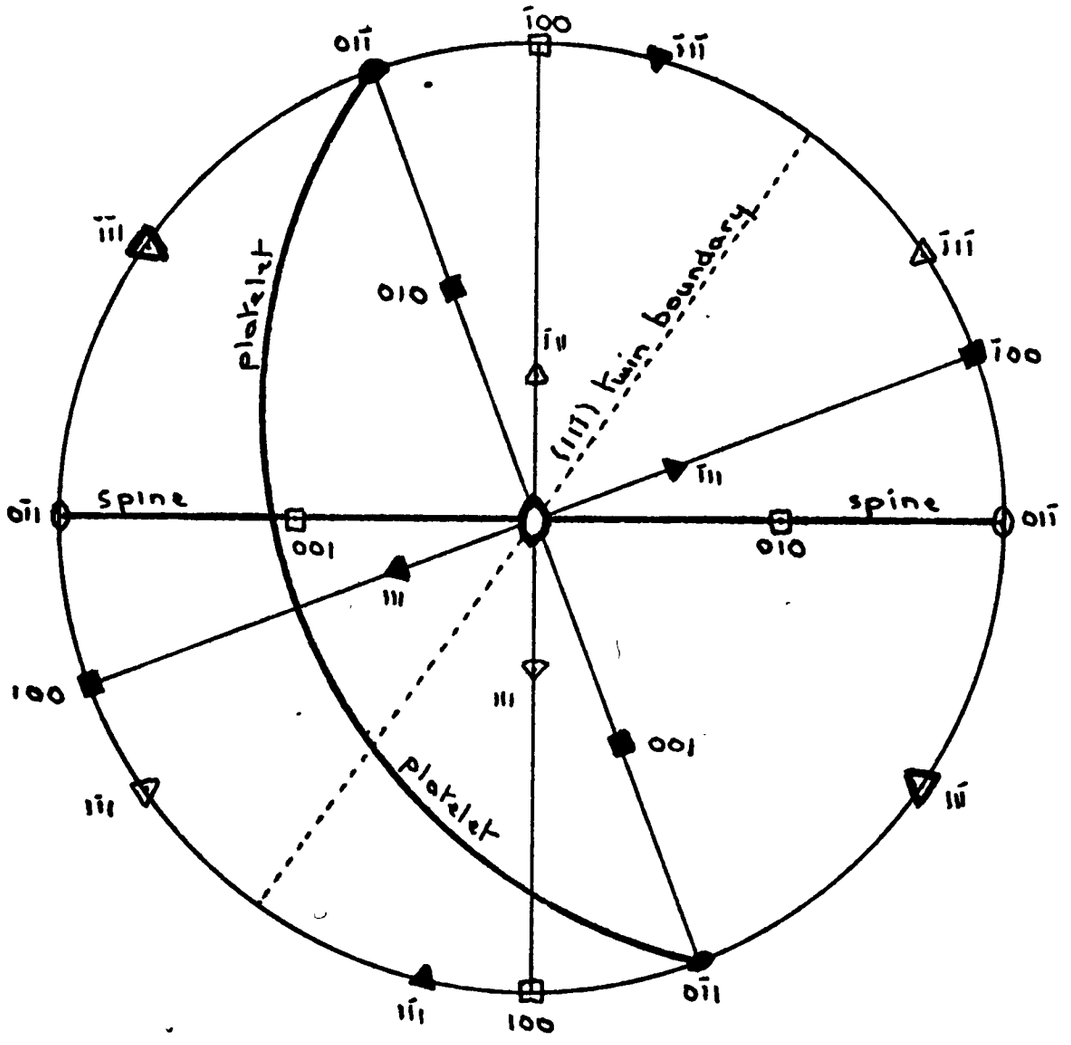


FIG. 94 [011] Stereographic Projection with an Axial $(11\bar{1})$ Spinel Twin showing the Spine/Platelet Relationship of a 1st Order Twinned Web (see fig. 93b)

A non-axial $(\bar{1}11)$ (white) is axially twinned across a $(11\bar{1})$ twin boundary to give the observed $(\bar{1}11)$ (black) platelets

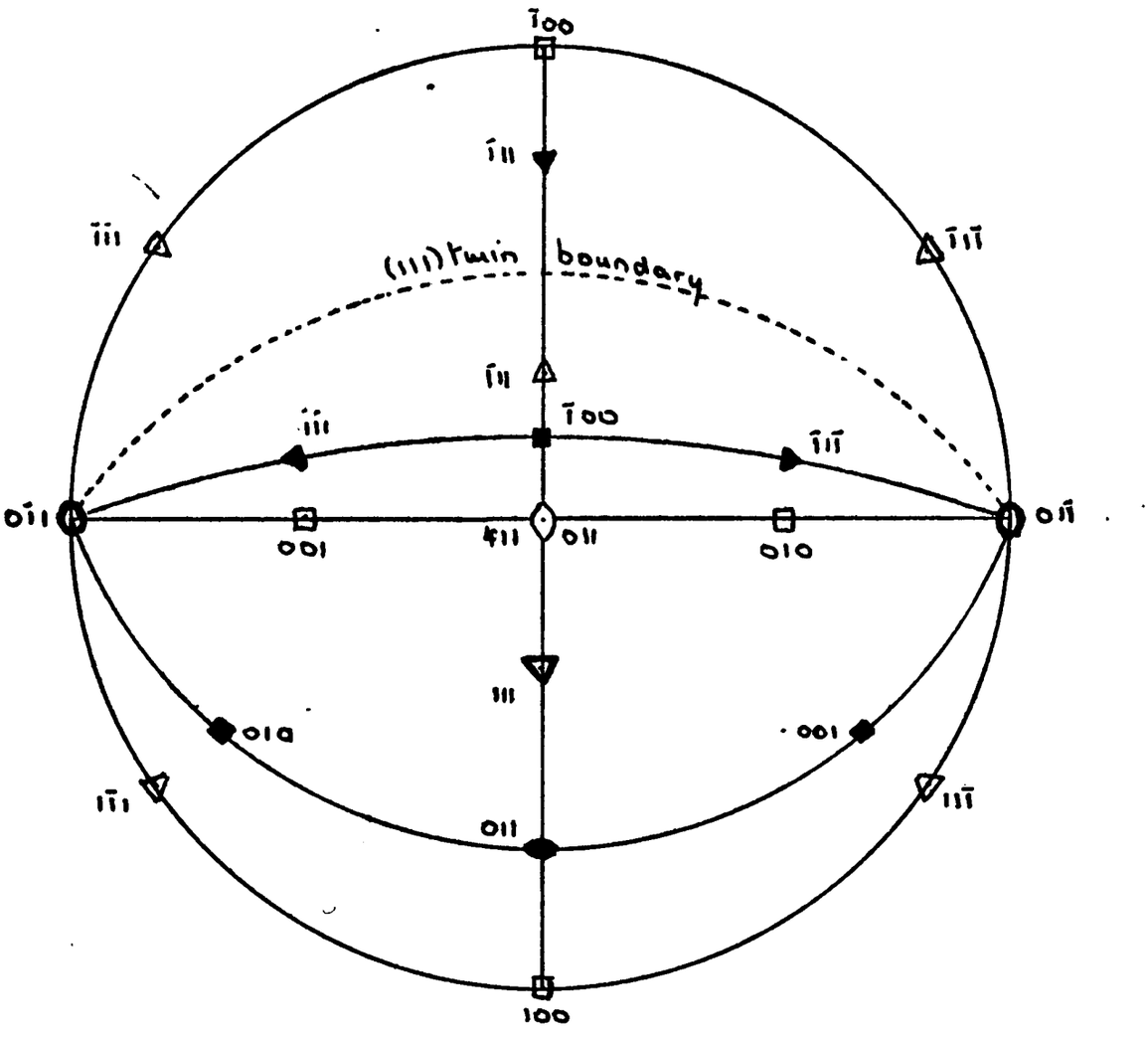


FIG. 95 [011] Stereographic Projection with a Non-axial (111) Spinel Twin

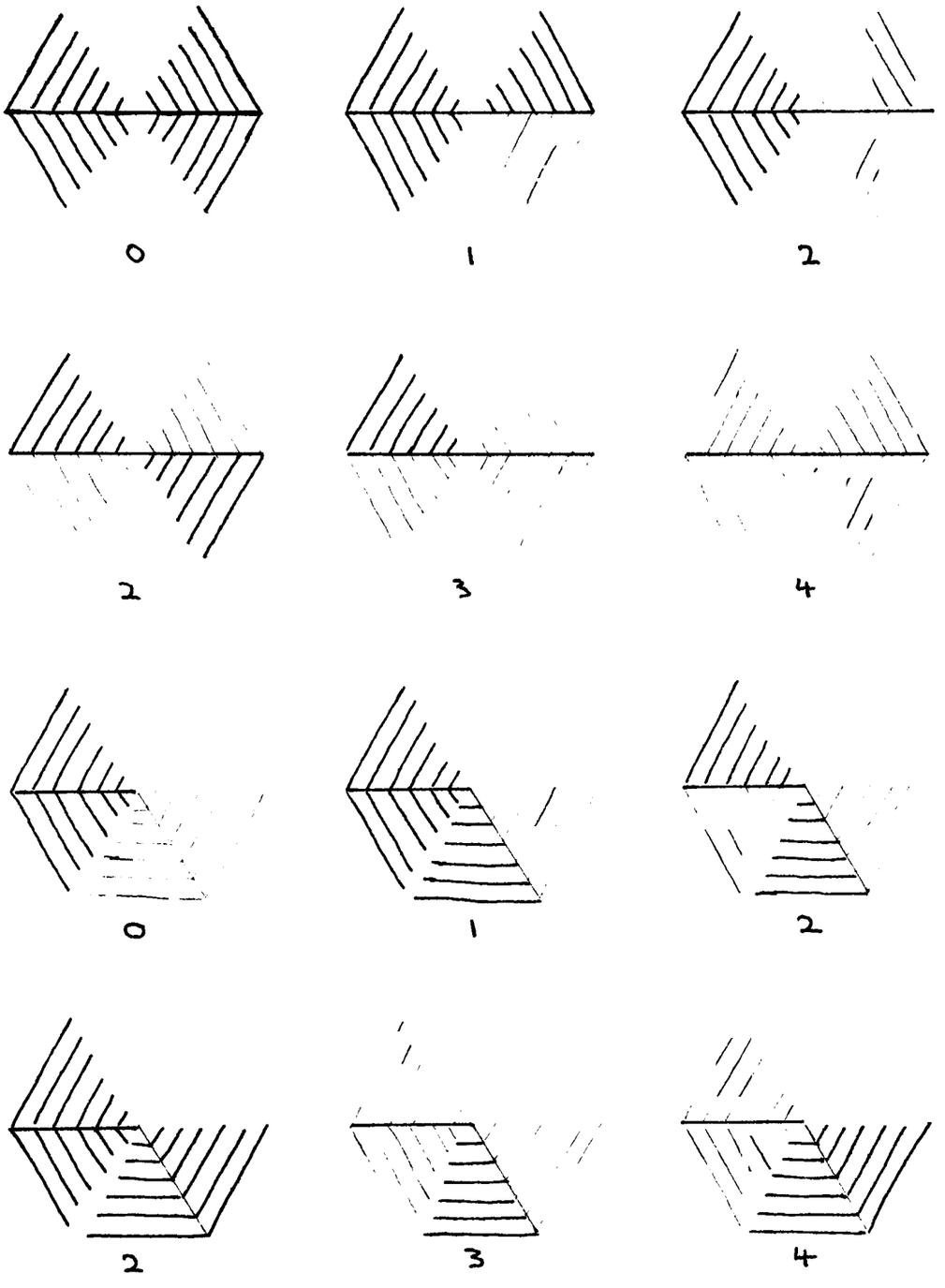


FIG. 96 Some Transverse Sections of Silicon Web Forms. (simple and 1st order twin spine/platelet relationships only) Red is related to black via an axial {111} spinel twin. The numbers indicate the number of inclined platelet systems. (see figs. 93)

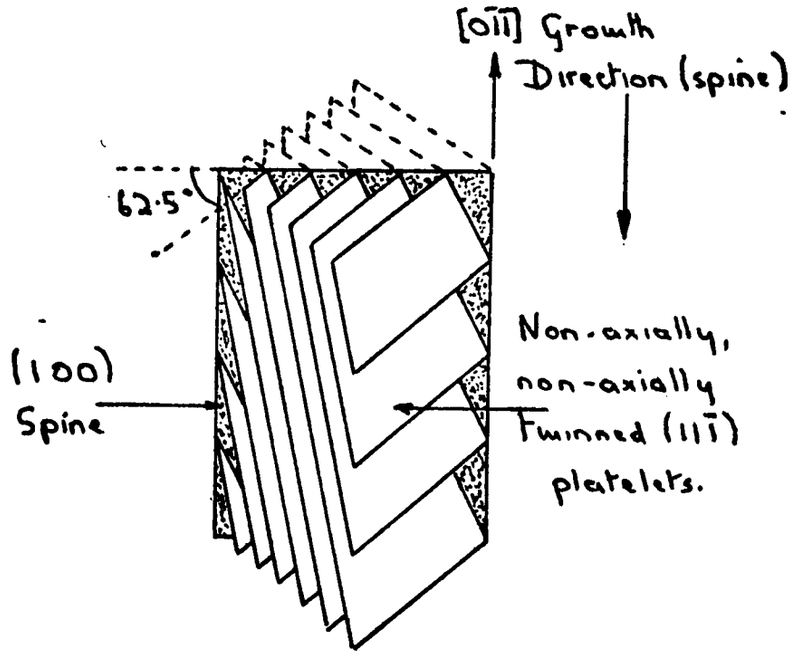


FIG. 97a A 2nd Order {111} Spinel Twinned Web
(see fig. 98)

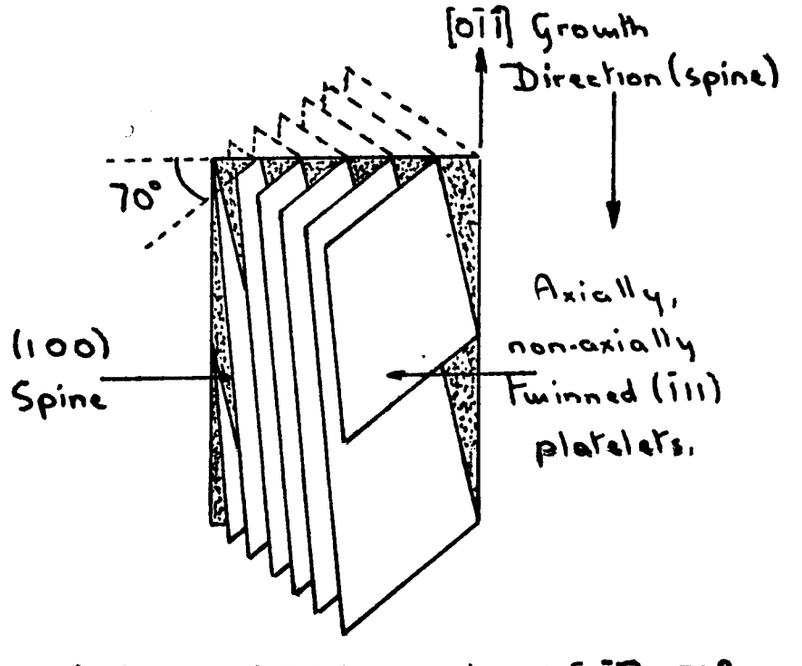


FIG. 97b Another 2nd Order {111} Spinel Twinned Web
(see fig. 100)

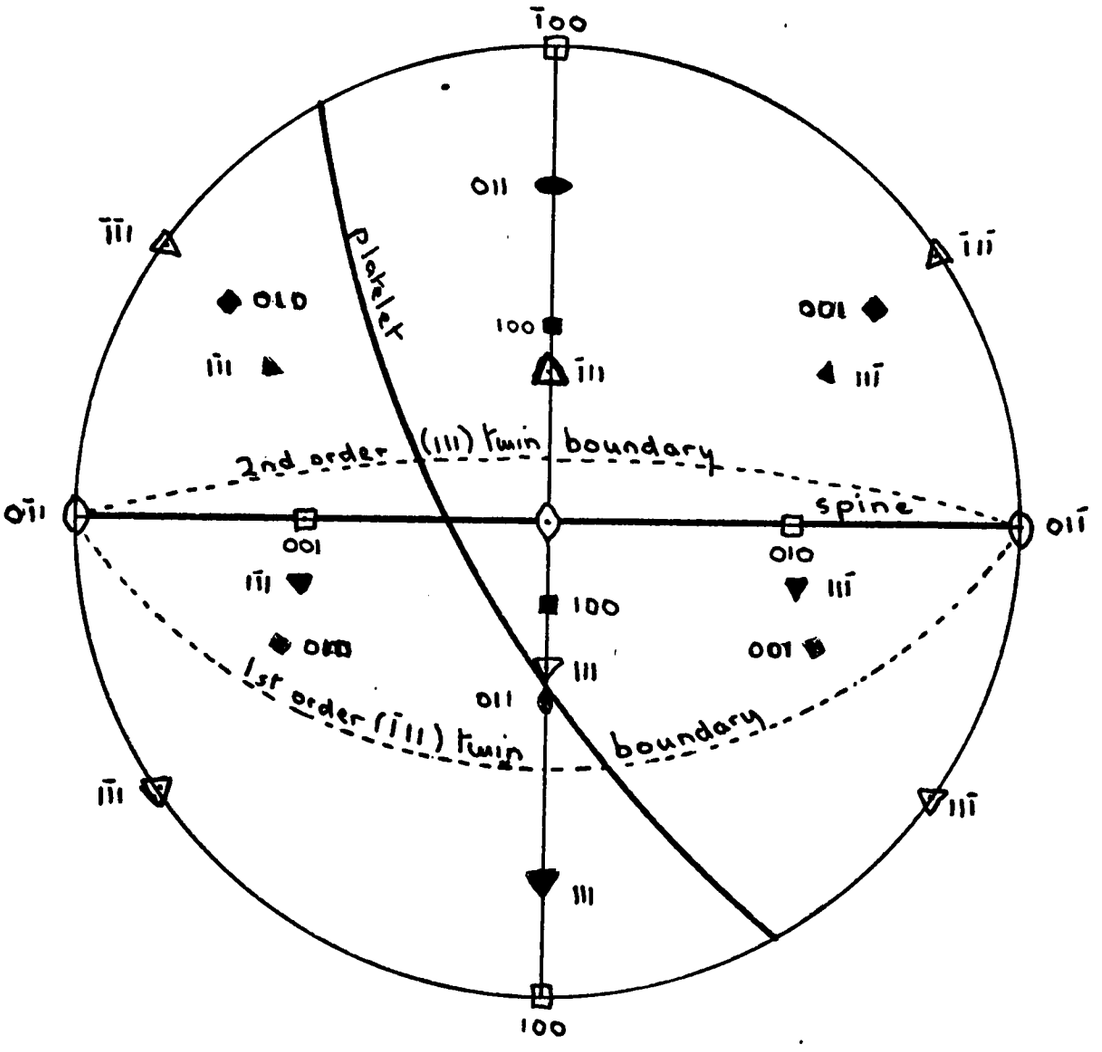


FIG. 98 [011] Stereographic Projection Showing the Spine/Platelet Relationship of a 2nd Order Twinned Web (see fig. 97a)

An axial $(11\bar{1})$ (white) is non-axially twinned across a 1st order $(\bar{1}11)$ twin boundary and then non-axially twinned across a 2nd order (111) twin boundary to give the observed $(11\bar{1})$ (red) platelets

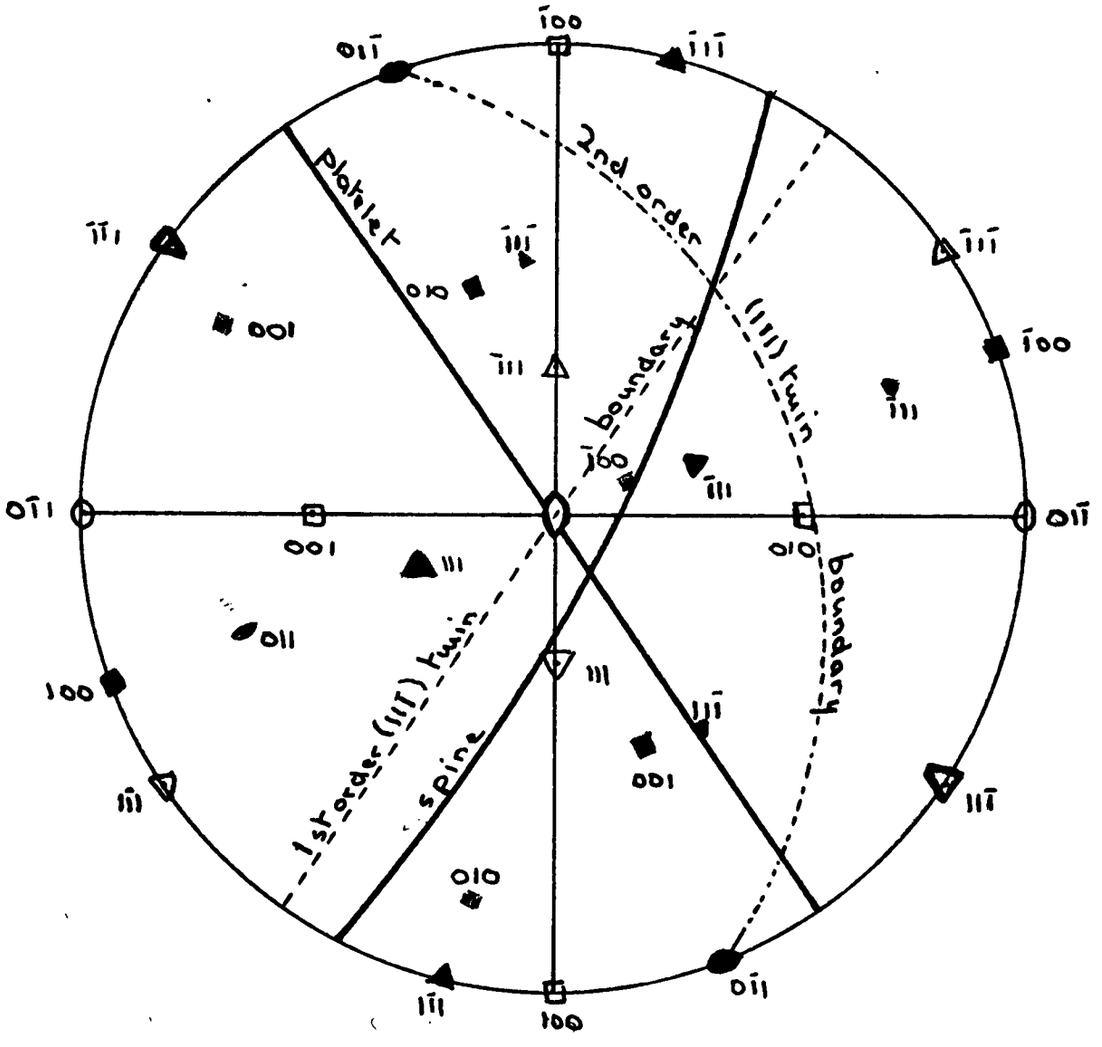


FIG. 99 [011] Stereographic Projection Showing the Spine/Platelet Relationship of a 2nd Order Twinned Web

A non-axial (001) (white) is axially twinned across a 1st order (11$\bar{1}$) twin boundary and then non-axially twinned across a 2nd order (111) twin boundary to give the observed (001) (red) spine

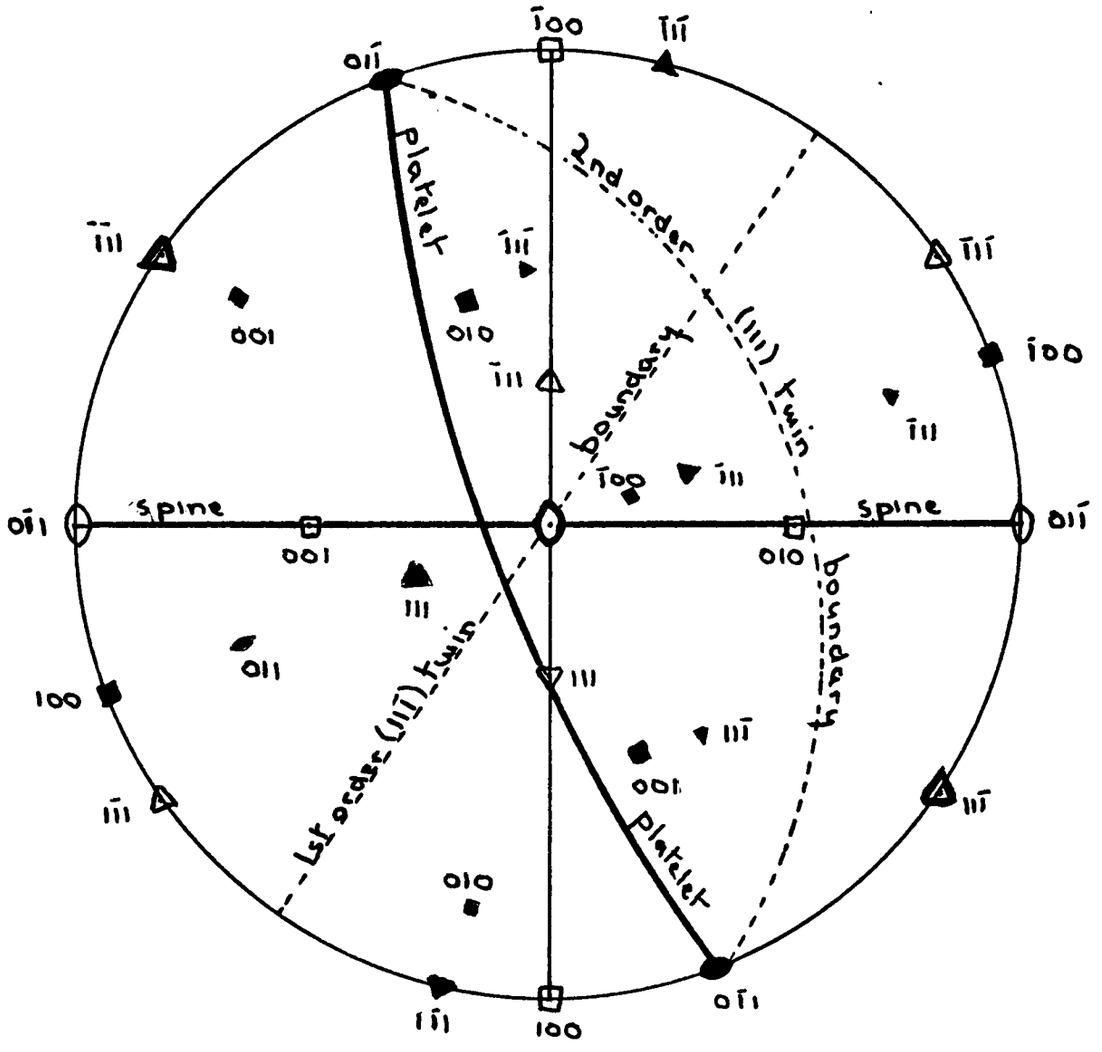
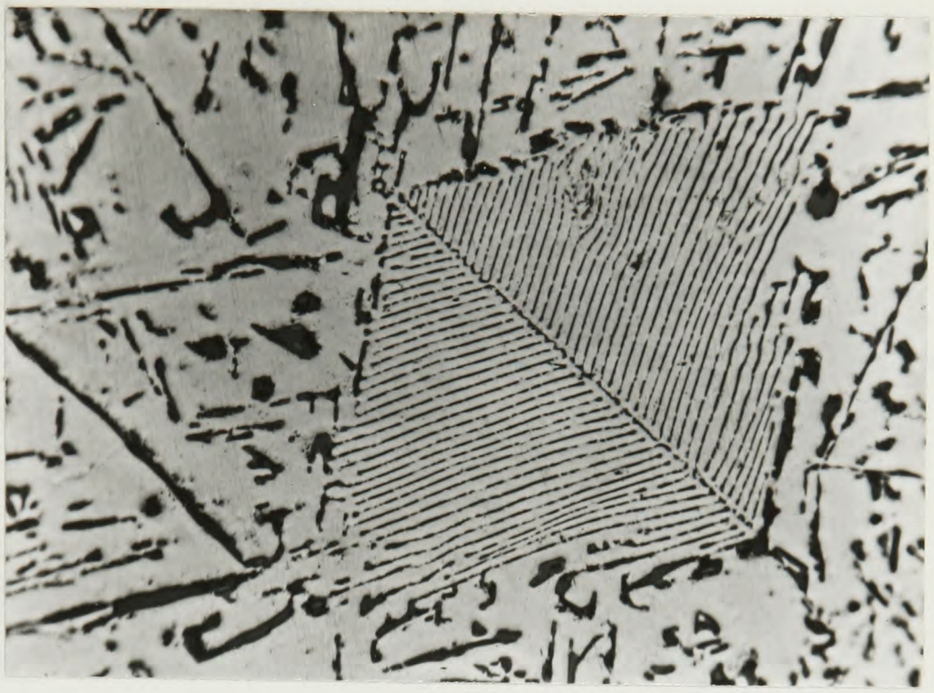


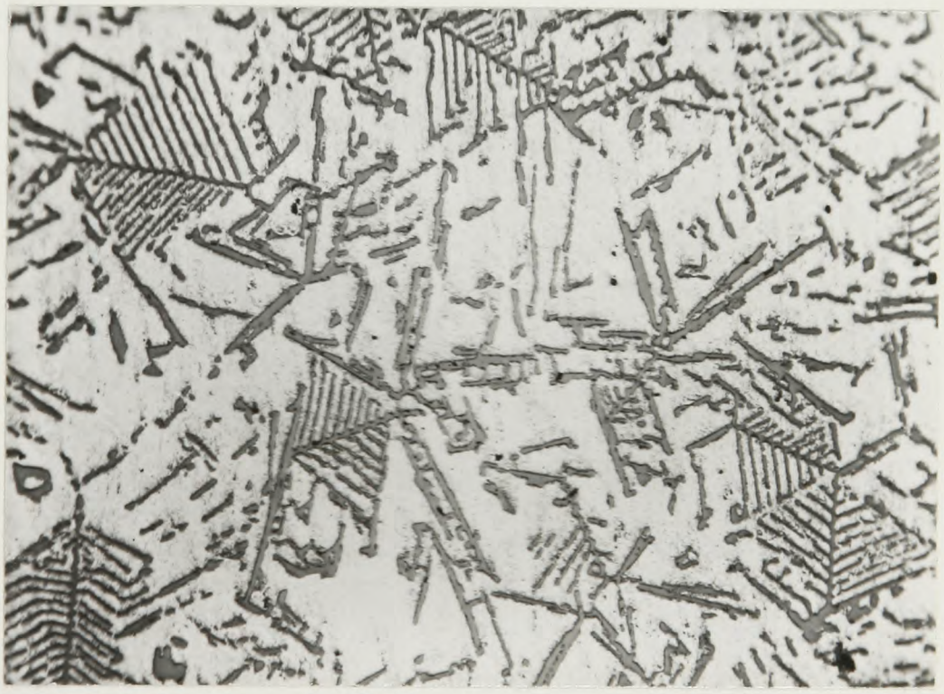
FIG. 100 [011] Stereographic Projection Showing the Spine/Platelet Relationship of a 2nd Order Twinned Web (see fig. 97b)

A non-axial ($\bar{1}11$) (white) is axially twinned across a 1st order (11$\bar{1}$) twin boundary and then non-axially twinned across a 2nd order (111) twin boundary to give the observed ($\bar{1}11$) (red) platelets



x 225

PLATE 101a Al/Si Eutectic - transverse section
($R = 3.7 \times 10^{-4}$ cm/sec., $G = 29.5^{\circ}$C/cm.)



x 225

PLATE 101b Al/Si Eutectic - transverse section
($R = 3.7 \times 10^{-4}$ cm/sec., $G = 120^{\circ}$C/cm.)

x 60

PLATE 102a Al/Si Eutectic - transverse section
($R = 1.30 \times 10^{-4}$ cm/sec., $G = 16.0^{\circ}$C/cm.)

x 60

PLATE 102b Al/Si Eutectic - longitudinal section
($R = 1.30 \times 10^{-4}$ cm/sec., $G = 16.0^{\circ}$C/cm.

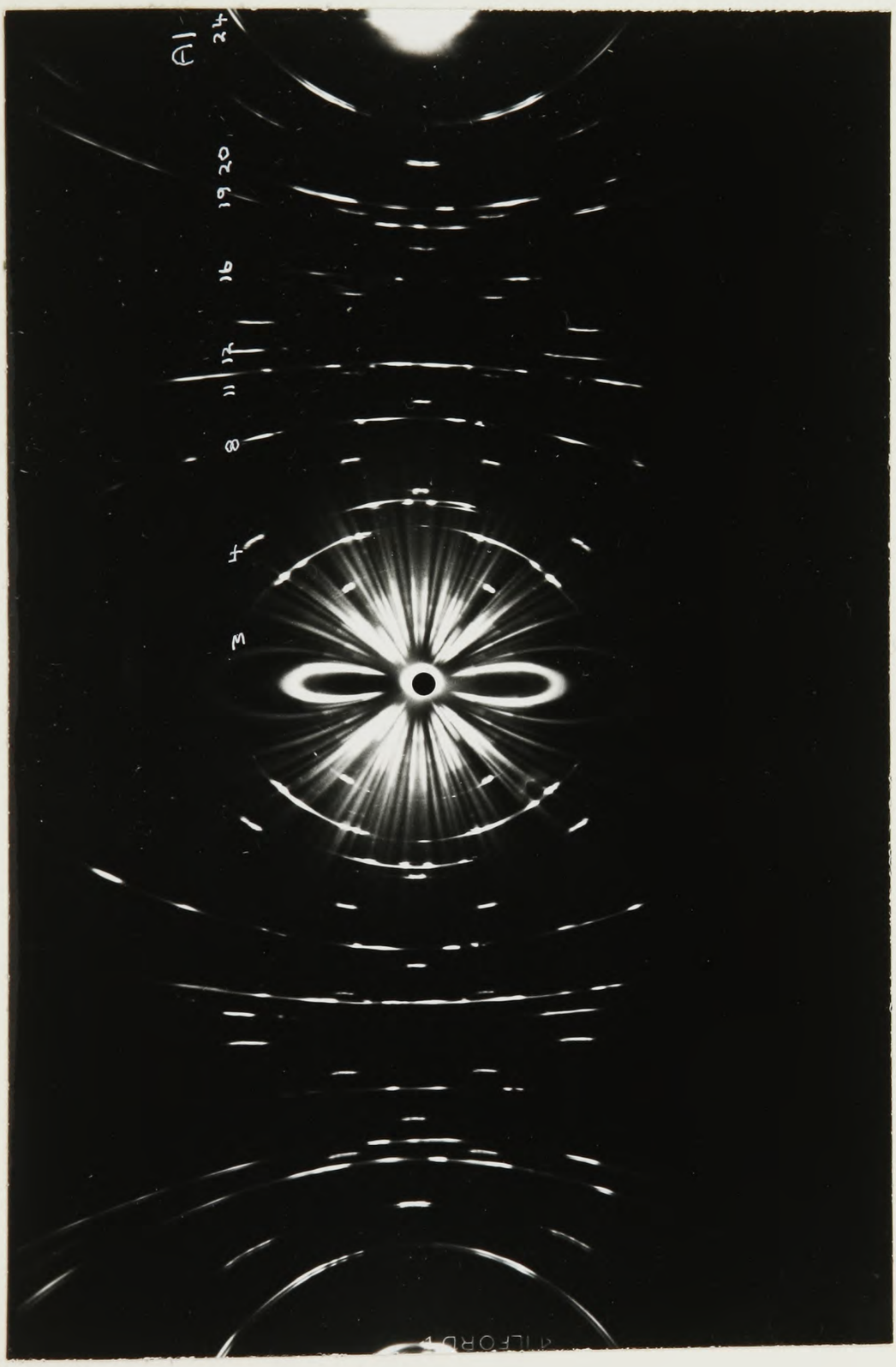
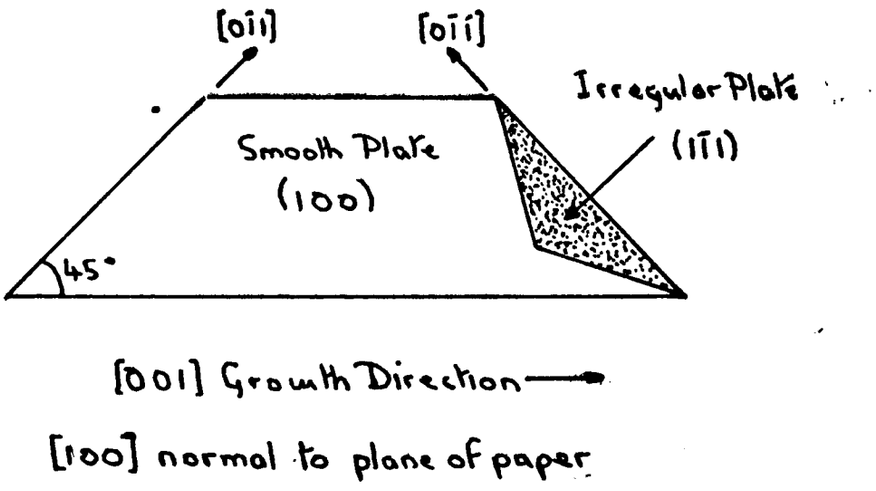


PLATE 103 X-Ray Rotation Photograph (Cu Kα radiation) about the Growth Axis of an Al/Si Eutectic Specimen

(R = 1.30×10^{-4} cm/sec., G = 29.5^{0}C/cm.)



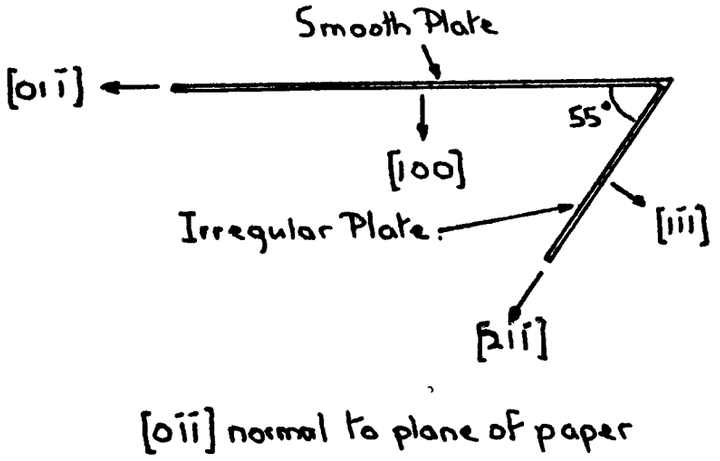


FIG. 104 Line Drawing of an Observed (100) Smooth Plate with an Irregular (1$\bar{1}$1) Plate attached

x 260

PLATE 105a Extracted Angular/Irregular Silicon
($R = 1.30 \times 10^{-4}$ cm/sec., $G = 16.0^{\circ}$C/cm.)

x 2,400

PLATE 105b Extracted Angular/Irregular Silicon
($R = 1.30 \times 10^{-4}$ cm/sec., $G = 16.0^{\circ}$C/cm.)

x 1,300

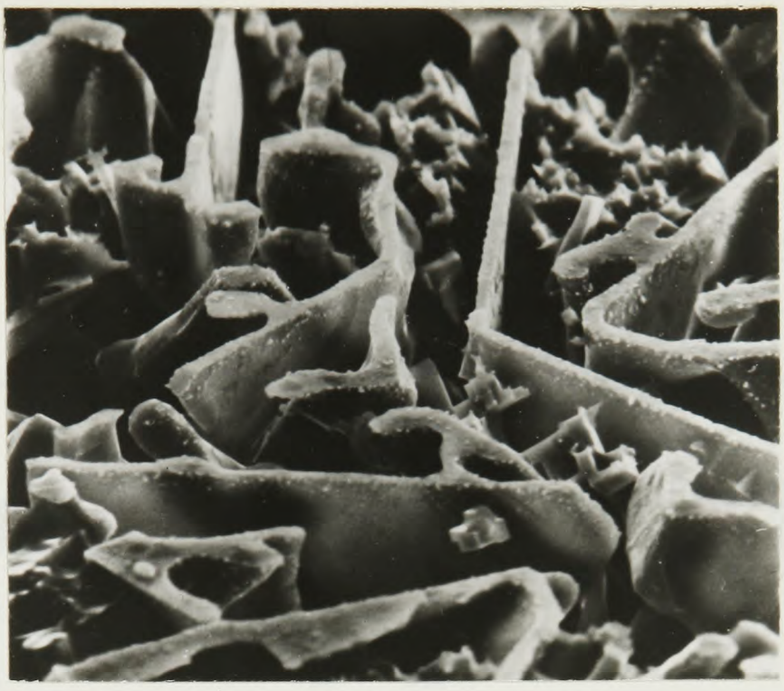
PLATE 106a Heavily Etched Al/Si Eutectic - growth direction normal to paper

($R = 1.30 \times 10^{-4}$ cm/sec., $G = 16.0^{\circ}$C/cm.)

x 1,300

PLATE 106b Heavily Etched Al/Si Eutectic - growth direction 40° to normal of paper

($R = 1.30 \times 10^{-4}$ cm/sec., $G = 16.0^{\circ}$C/cm.)

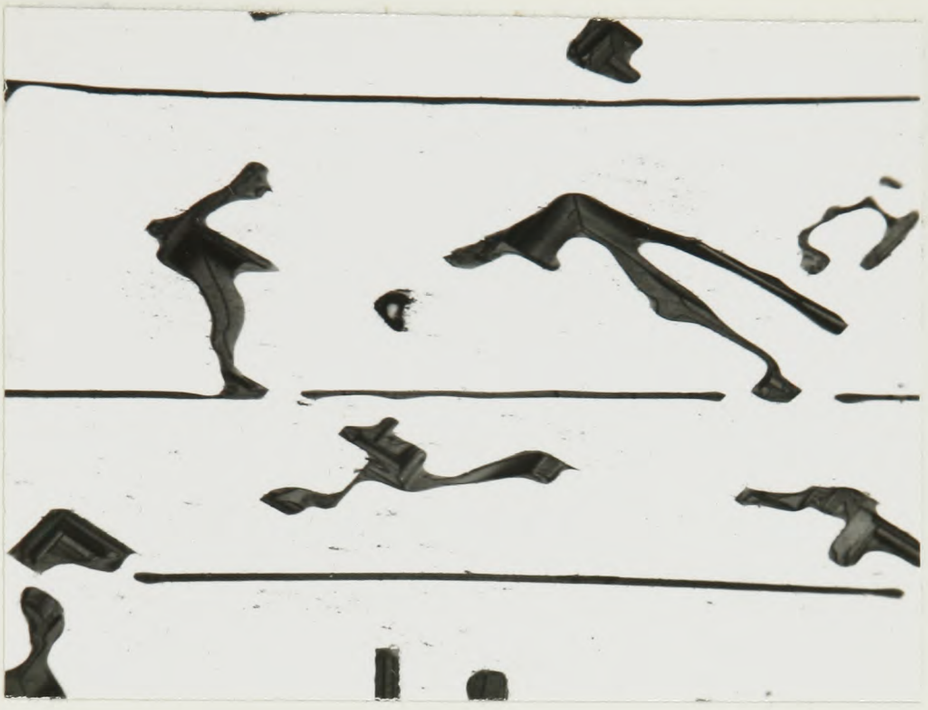


x 1,300

PLATE 107a Heavily Etched Al/Si Eutectic - growth direction 60° to normal of paper
($R = 1.30 \times 10^{-4}$ cm/sec., $G = 16^{\circ}C$/cm.)

x 1,300

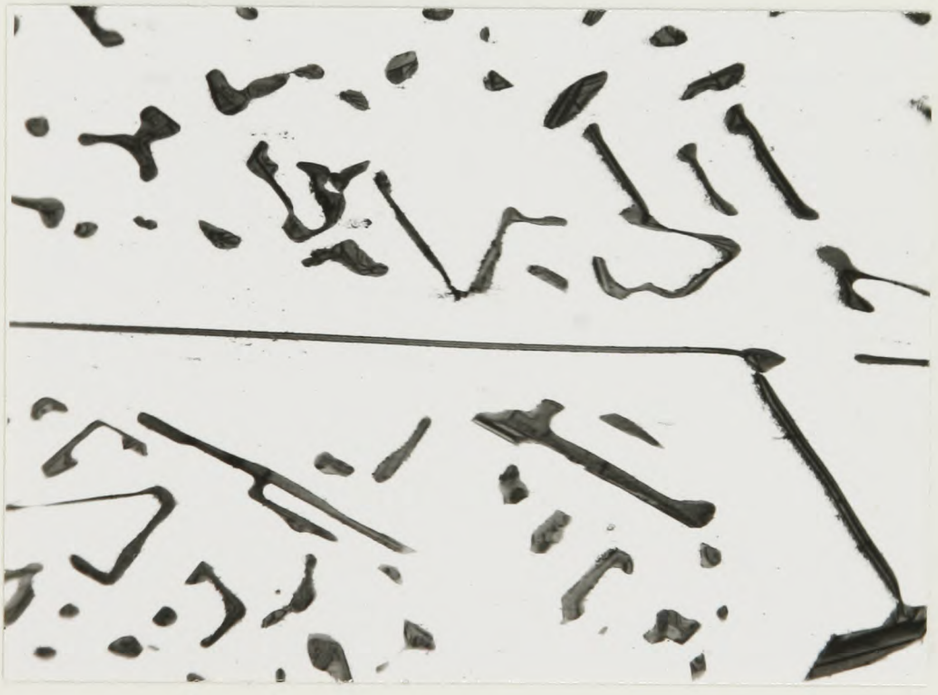
PLATE 107b Heavily Etched Al/Si Eutectic - growth direction 80° to normal of paper
($R = 1.30 \times 10^{-4}$ cm/sec., $G = 16^{\circ}C$/cm.)



x 225

PLATE 108a C.P.4. Etched Al/Si Eutectic - longitudinal section

($R = 2.78 \times 10^{-5}$ cm/sec., $G = 3.5^{\circ}$C/cm.)



x 225

PLATE 108b C.P.4. Etched Al/Si Eutectic - longitudinal section

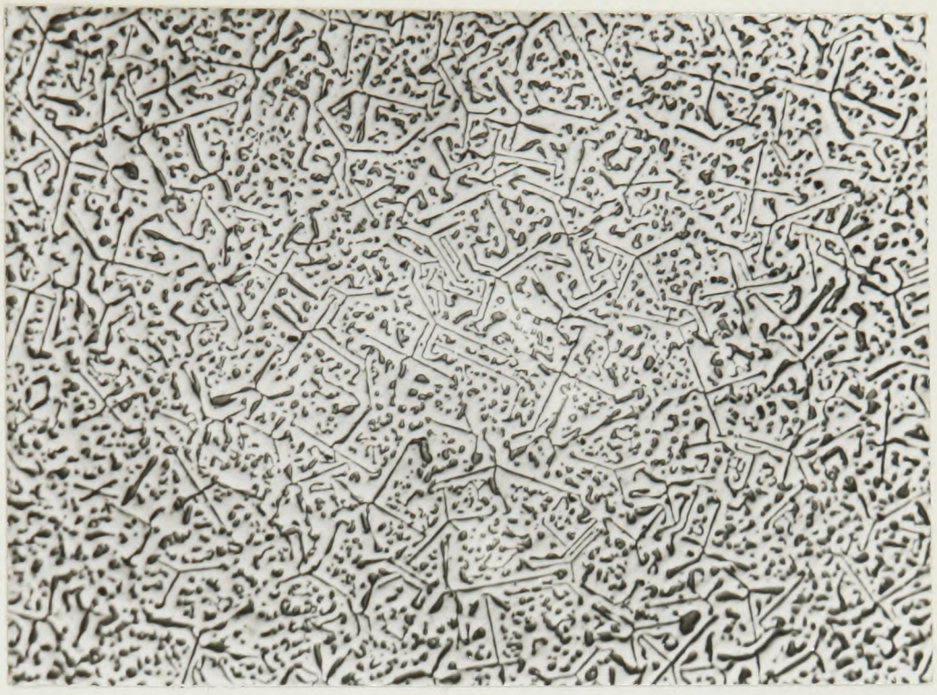
($R = 2.78 \times 10^{-5}$ cm/sec., $G = 3.5^{\circ}$C/cm.)

x 125

PLATE 109a Anodised Al/Si Eutectic - transverse section
($R = 1.54 \times 10^{-5}$ cm/sec., $G \cong 30^{\circ}C$/cm.)

x 125

PLATE 109b Anodised Al/Si Eutectic - transverse section
($R = 1.54 \times 10^{-5}$ cm/sec., $G \cong 30^{\circ}C$/cm.)

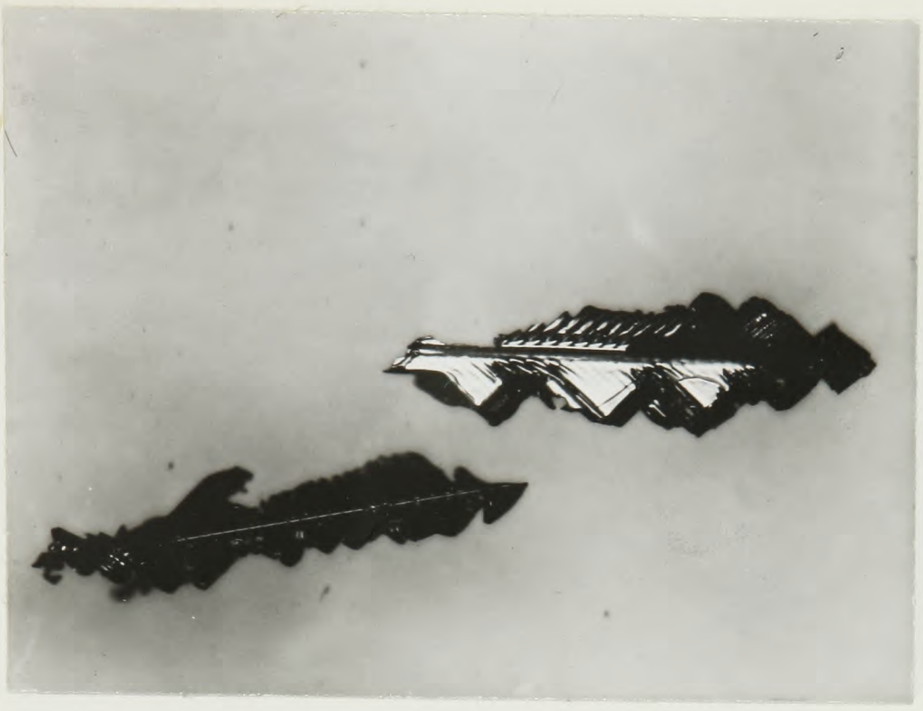


x 60

PLATE 110a Ag/Si Eutectic - transverse section
($R = 2.78 \times 10^{-5}$ cm/sec., $G \cong 30^{\circ}C$/cm.)

x 60

PLATE 110b Ag/Si Eutectic - longitudinal section
($R = 2.78 \times 10^{-5}$ cm/sec., $G \cong 30^{\circ}C$/cm.)



x 60

PLATE 111a Extracted Silicon Particles
($R = 2.78 \times 10^{-5}$ cm/sec., $G \cong 30^{\circ}C$/cm.)

x 125

PLATE 111b Extracted Silicon Particle
($R = 2.78 \times 10^{-5}$ cm/sec., $G \cong 30^{\circ}C$/cm.)

x 125

PLATE 112a Extracted Silicon Particles
($R = 2.78 \times 10^{-5}$ cm/sec., $G \cong 30^{\circ}C$/cm.)

x 60

PLATE 112b Extracted Silicon Particles
($R = 2.78 \times 10^{-5}$ cm/sec., $G \cong 30^{\circ}C$/cm.)

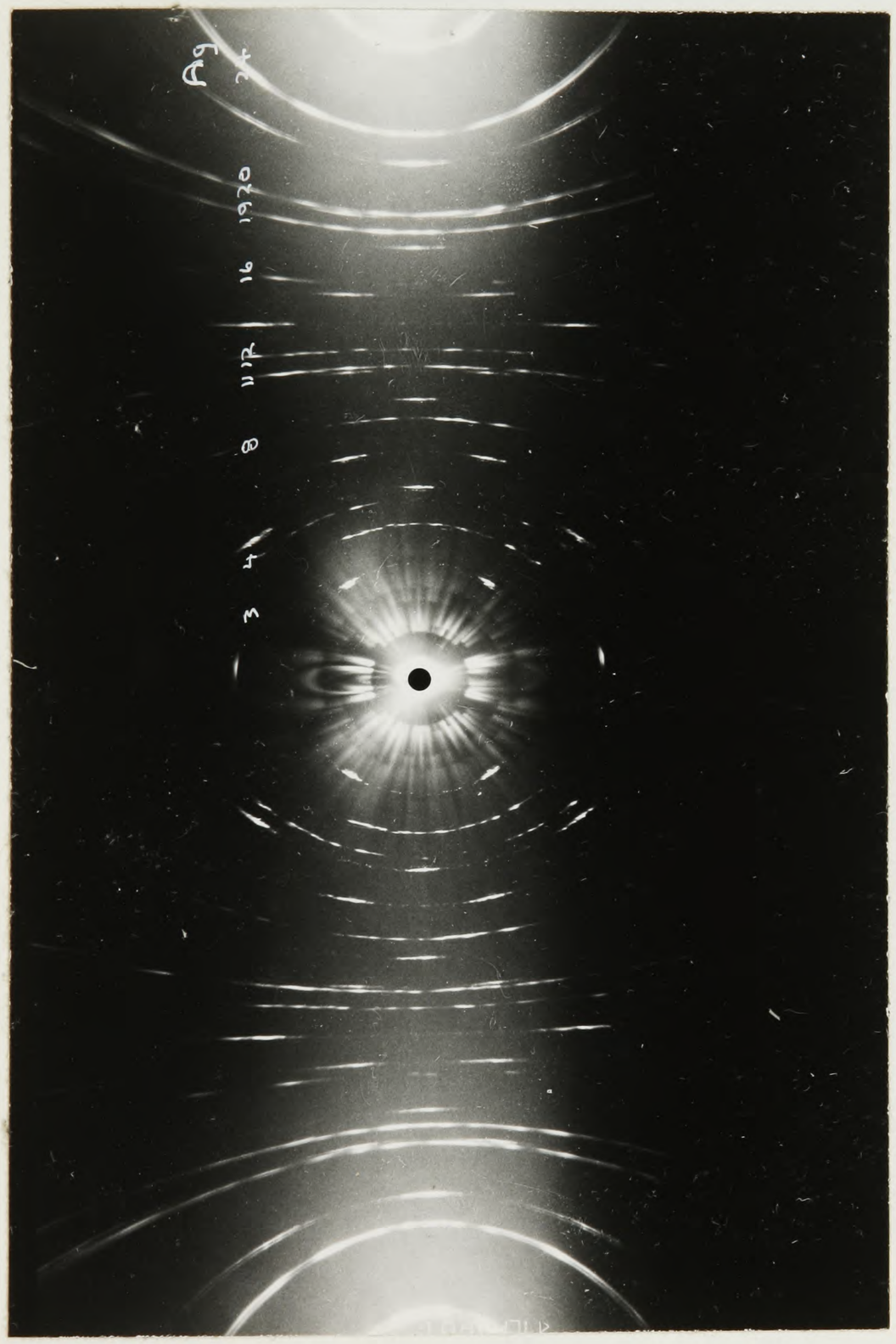
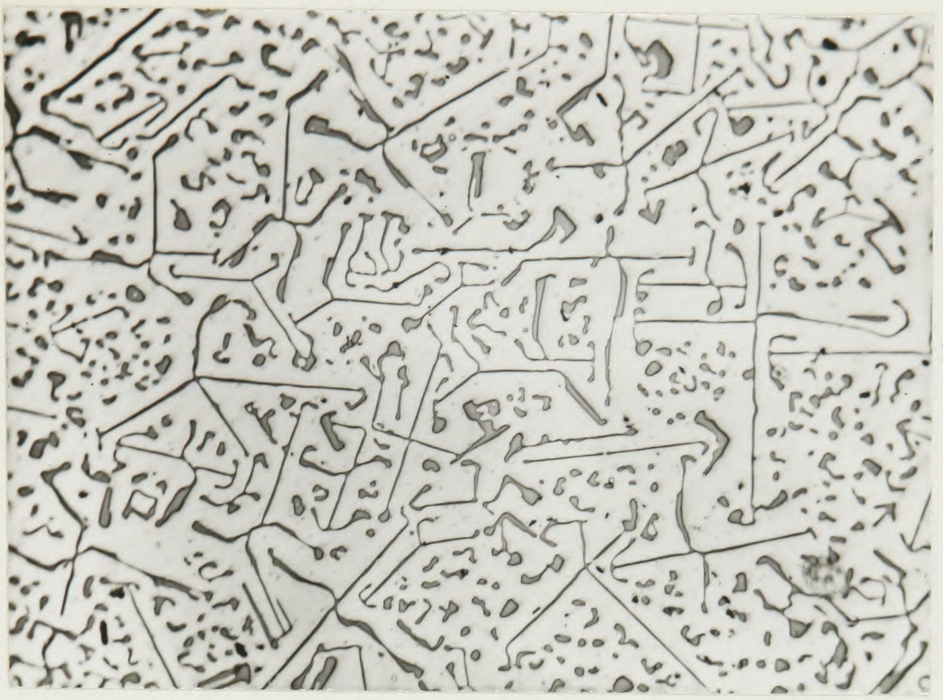


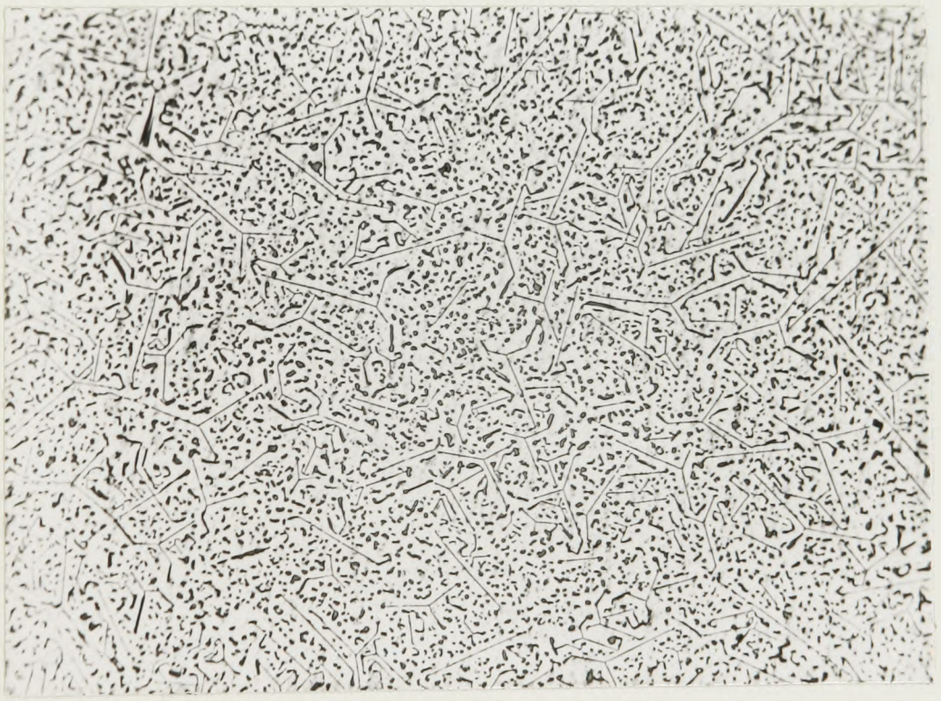
PLATE 113 X-Ray Rotation Photograph (Cu Kα radiation) about the Growth Axis of a Ag/Si Eutectic Specimen

($R = 2.78 \times 10^{-5}$ cm/sec., $G \cong 30^{0}$C/cm.)



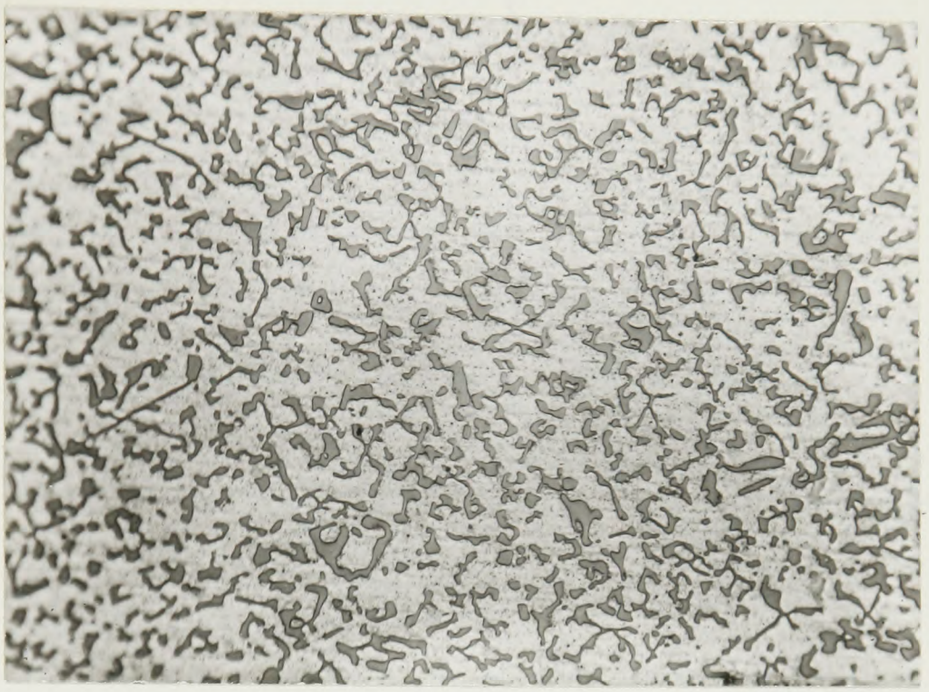
x 125

PLATE 114a Ag/Si Eutectic - transverse section
($R = 2.78 \times 10^{-5}$ cm/sec., $G \simeq 30^{\circ}C$/cm.)



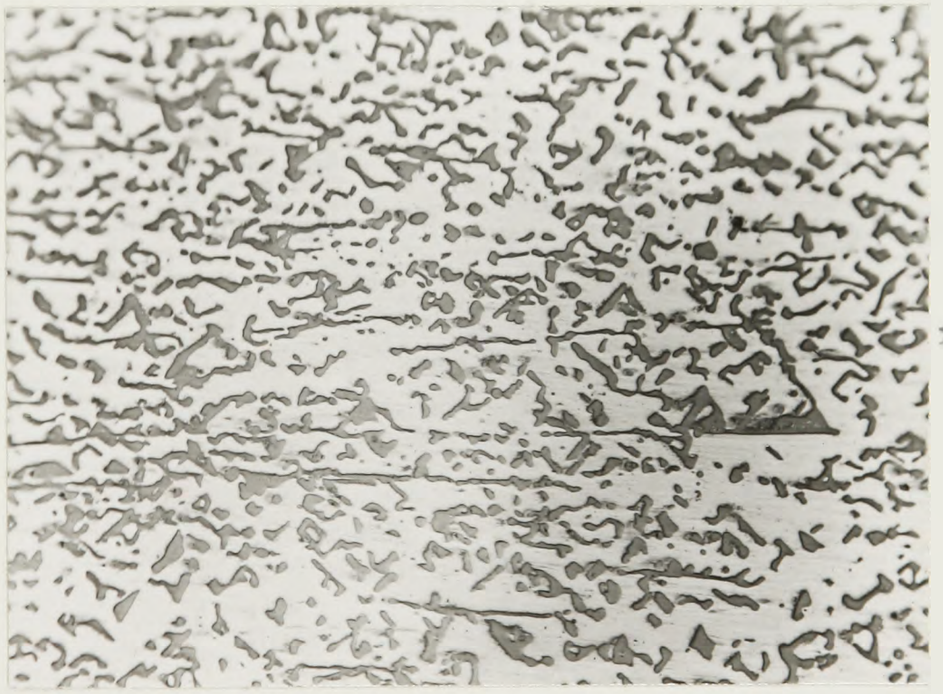
x 125

PLATE 114b Ag/Si Eutectic - transverse section
($R = 7.41 \times 10^{-4}$ cm/sec., $G \simeq 30^{\circ}C$/cm.)



x 225

PLATE 115a Au/Si Eutectic - transverse section
($R = 2.78 \times 10^{-5}$ cm/sec., $G \cong 30^{\circ}C$/cm.)



x 225

PLATE 115b Au/Si Eutectic - longitudinal section
($R = 2.78 \times 10^{-5}$ cm/sec., $G \cong 30^{\circ}C$/cm.)

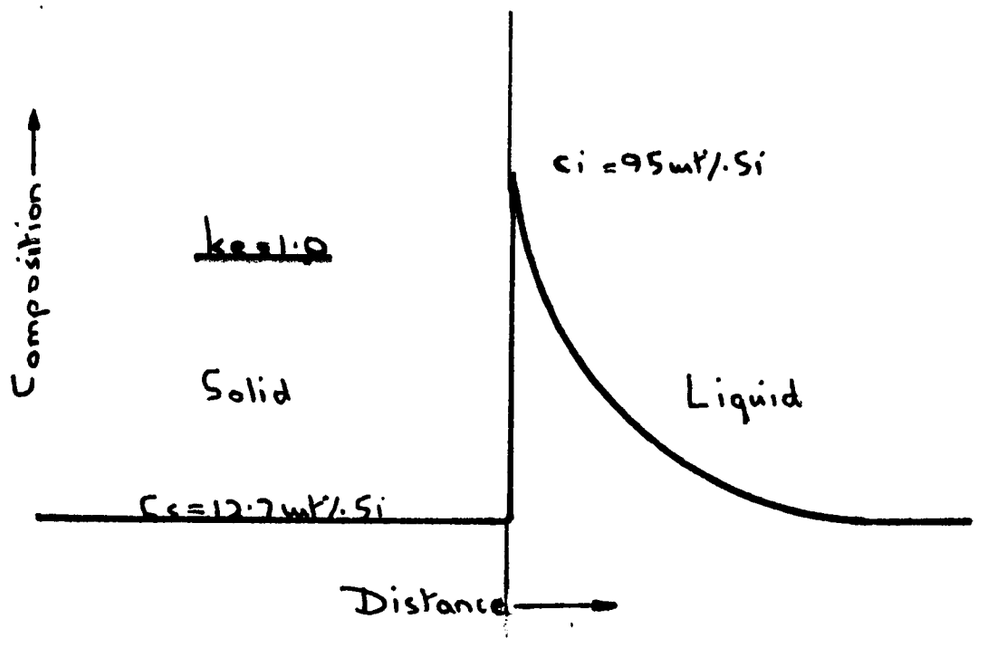


FIG. 116a

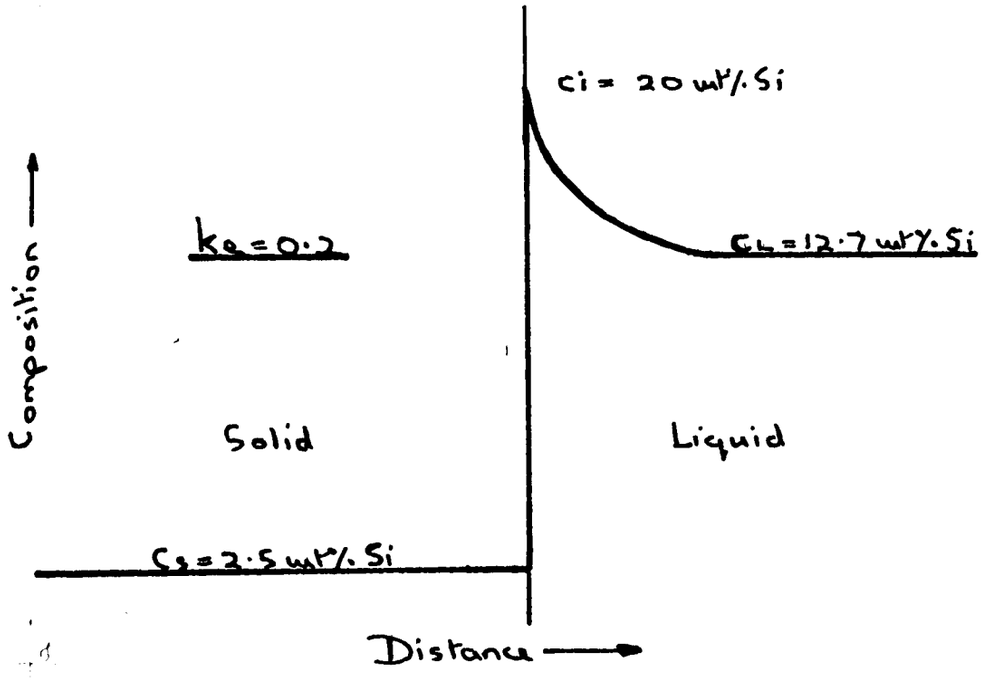


FIG. 116b

Solute Distribution Curves for Al/Si Eutectic Alloy growing with a Planar Aluminium Growth Front

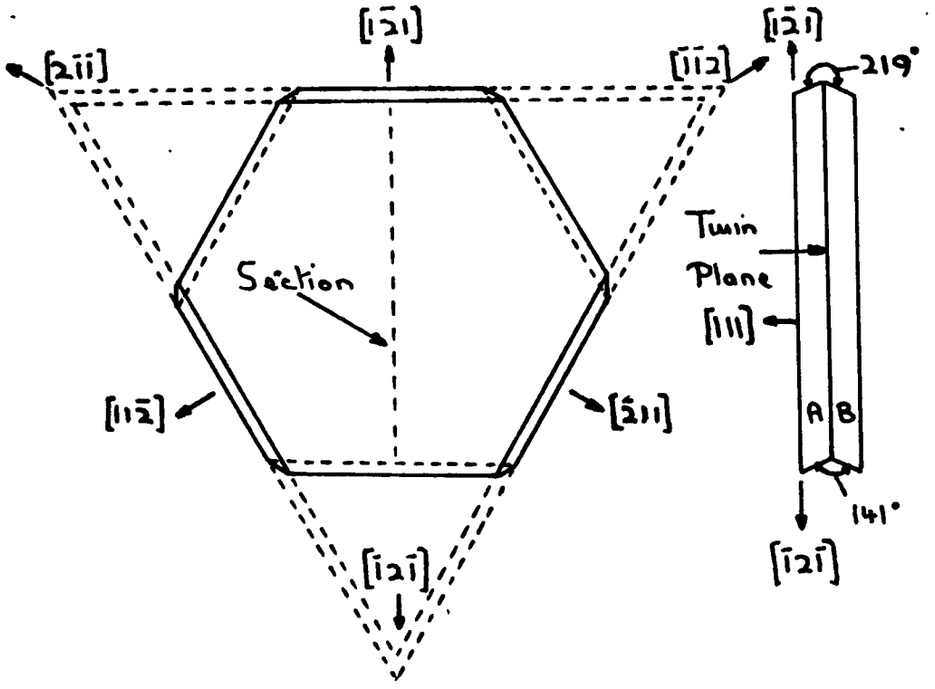


FIG. 117a A Silicon Particle containing One Twin Plane (c.f. fig. 74a)

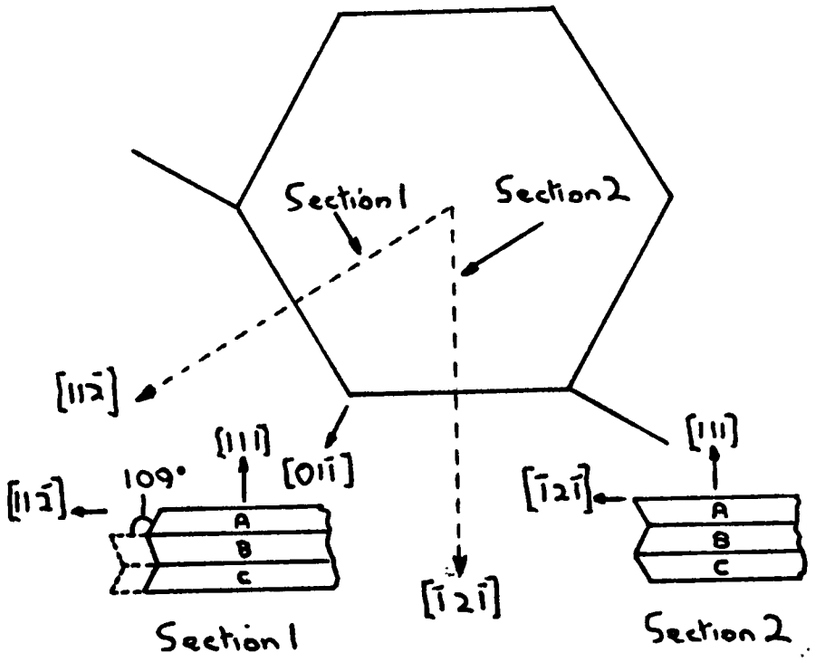
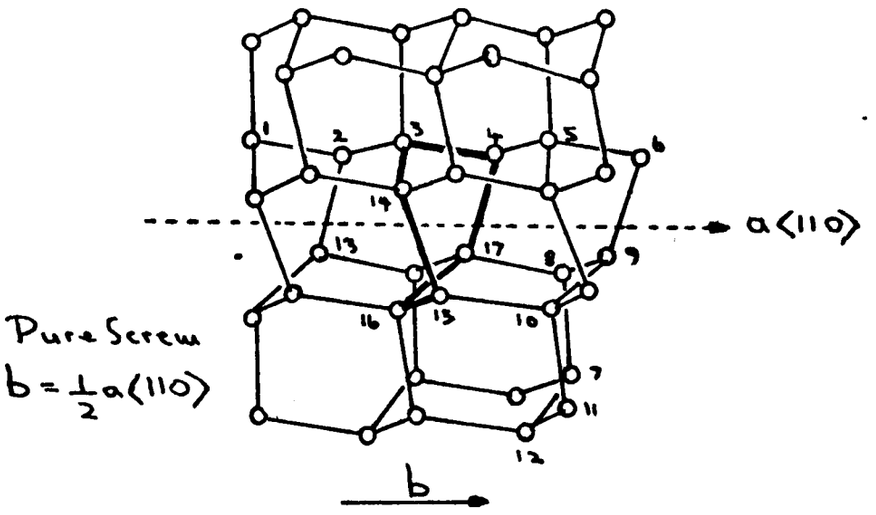


FIG. 117b A Silicon Particle containing Two Twin Planes (c.f. fig. 74b)



Screw character seen by comparing normal hexagon 7,8,9,10,11,12,7 with 13,2,3,14,15,16,17.

FIG. 118a A Model of a $\frac{1}{2}$ a ⟨110⟩ Screw Dislocation in A Diamond Cubic Material. (after Hornstra 1958)

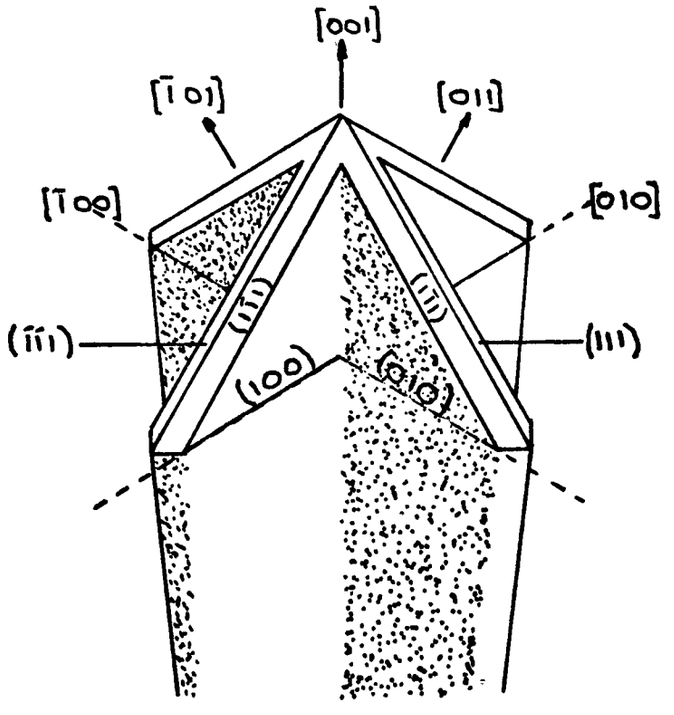


FIG. 118b A Model of the Proposed Growth Front for Angular Eutectic Silicon Particles

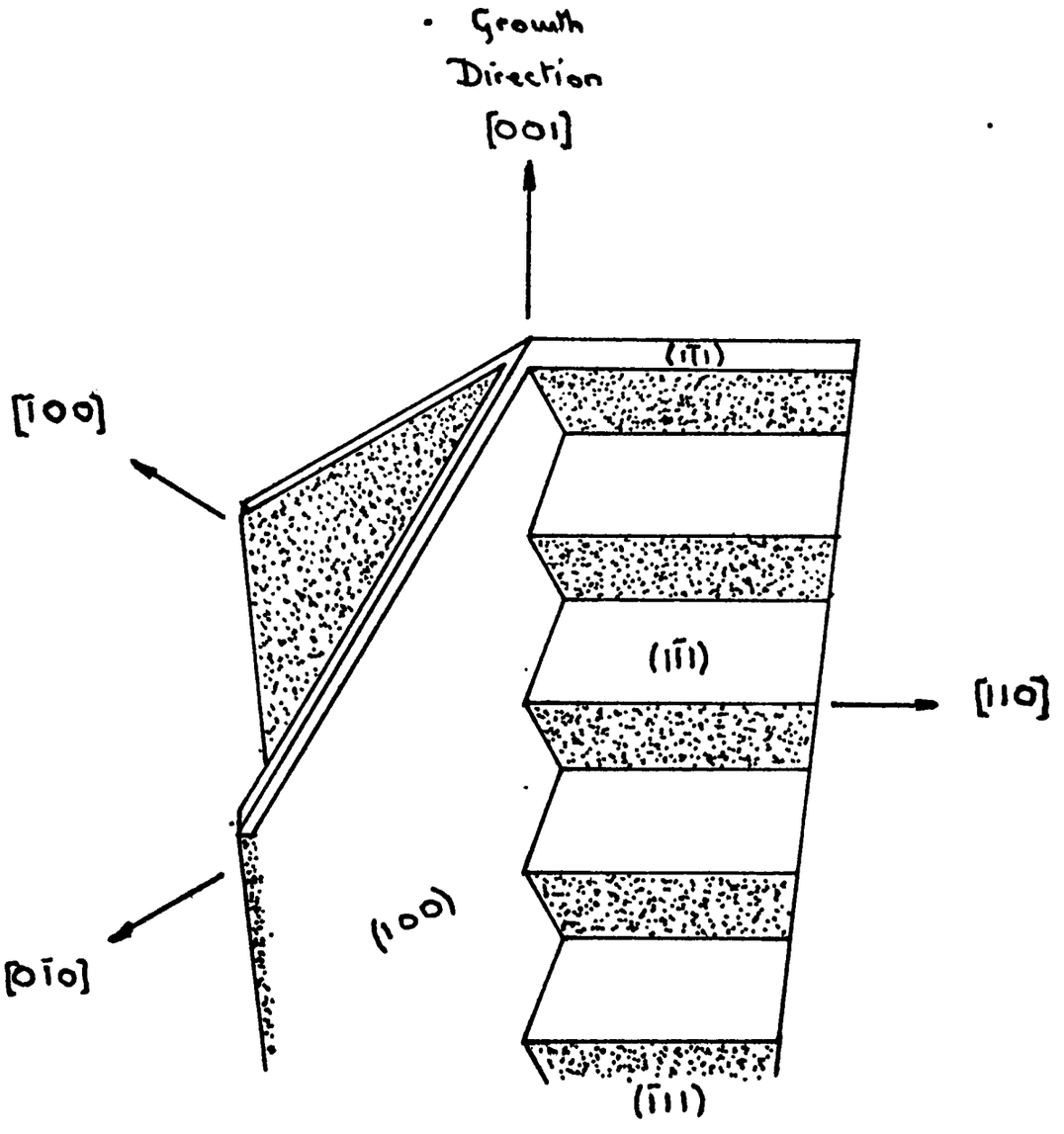


FIG. 119 Model showing the Proposed Growth Front for Angular Eutectic Silicon Particles containing a Corrugated Side Plate

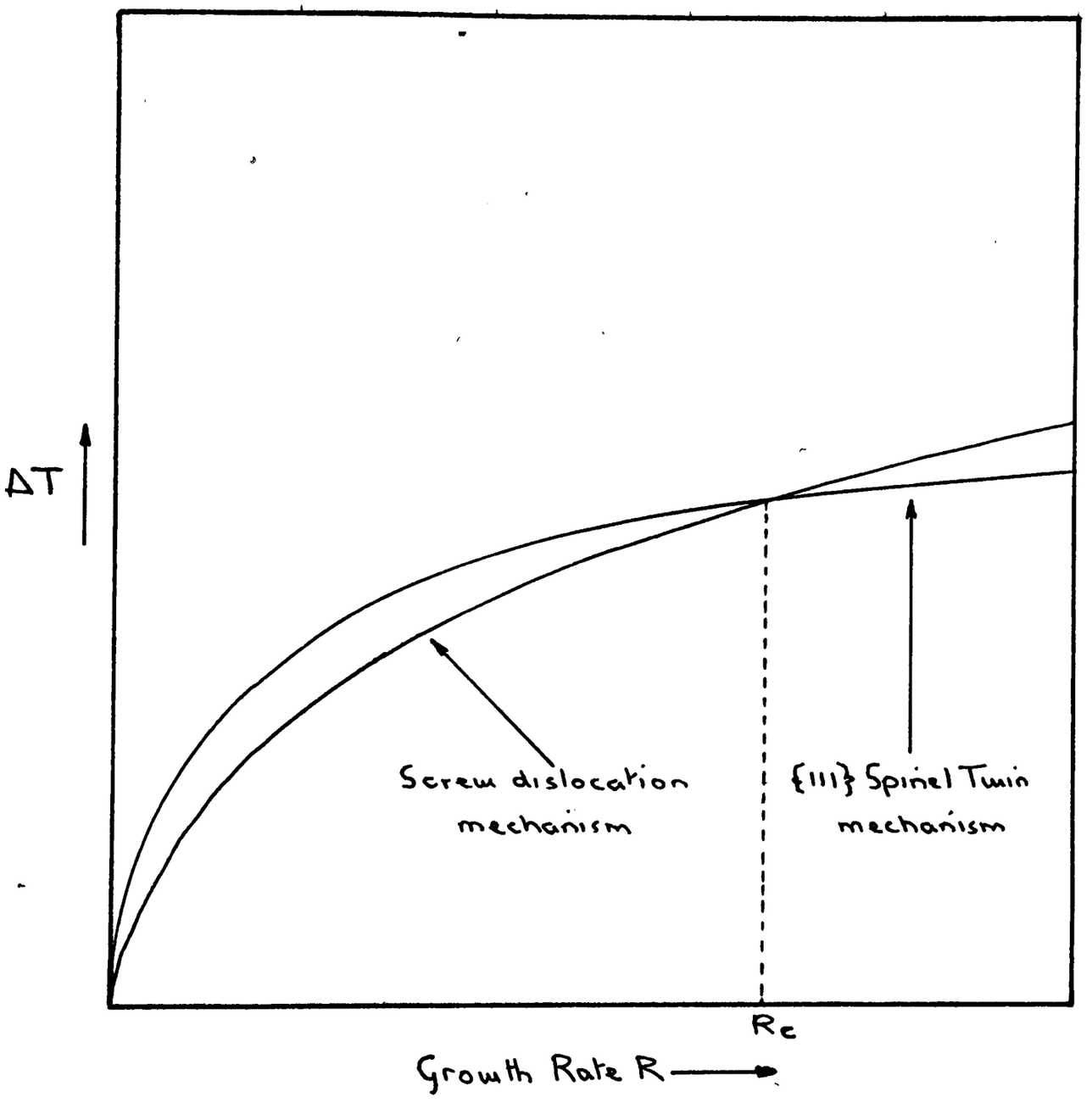
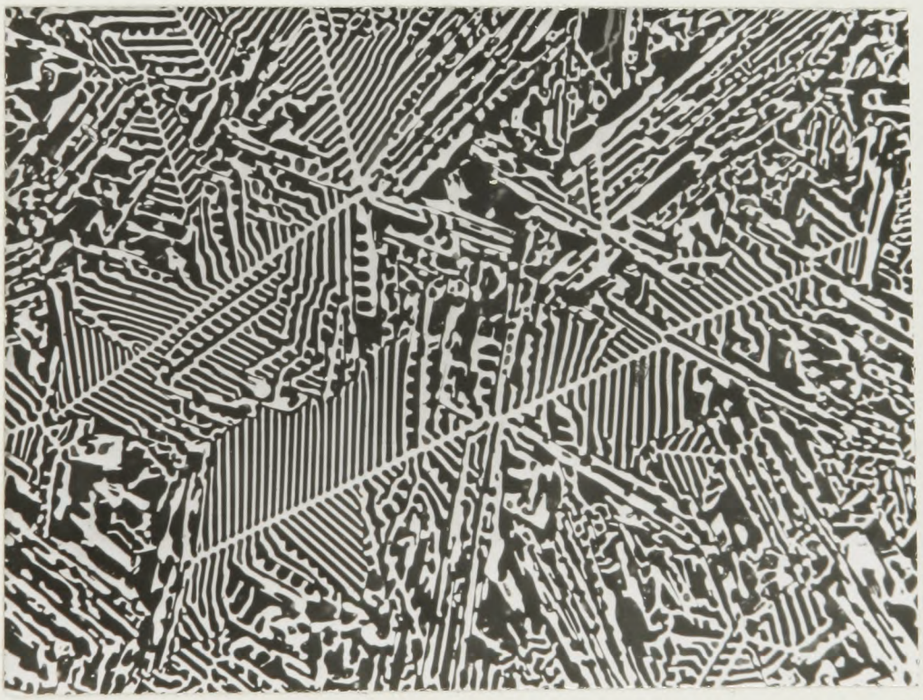


FIG. 120 A Graph showing a Possible Relationship between the Undercooling (Δ T) and the Imposed Growth Rate (R) for Screw Dislocation and Spinel Twin based Mechanisms

x 500

PLATE 121a Al/Ce Eutectic - longitudinal section
($R = 2.5 \times 10^{-6}$ cm/sec., $G \simeq 30^{\circ}$C/cm.)
(after Hellawell 1967a)



x 100

PLATE 121b Al/Ce Eutectic - transverse section
($R = 3 \times 10^{-5}$ cm/sec., $G \simeq 30^{\circ}$C/cm.)
(after Hellawell 1967a)

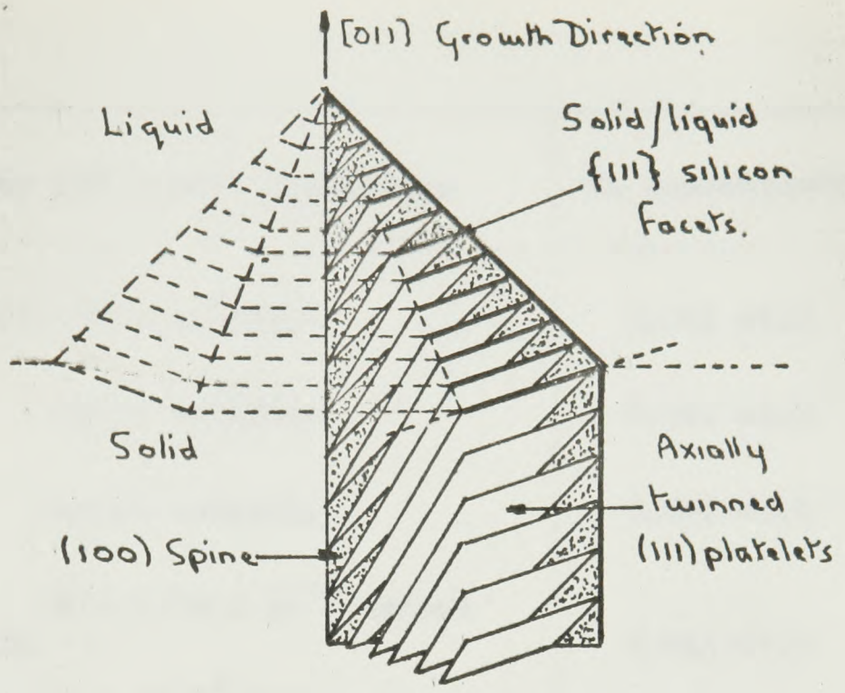
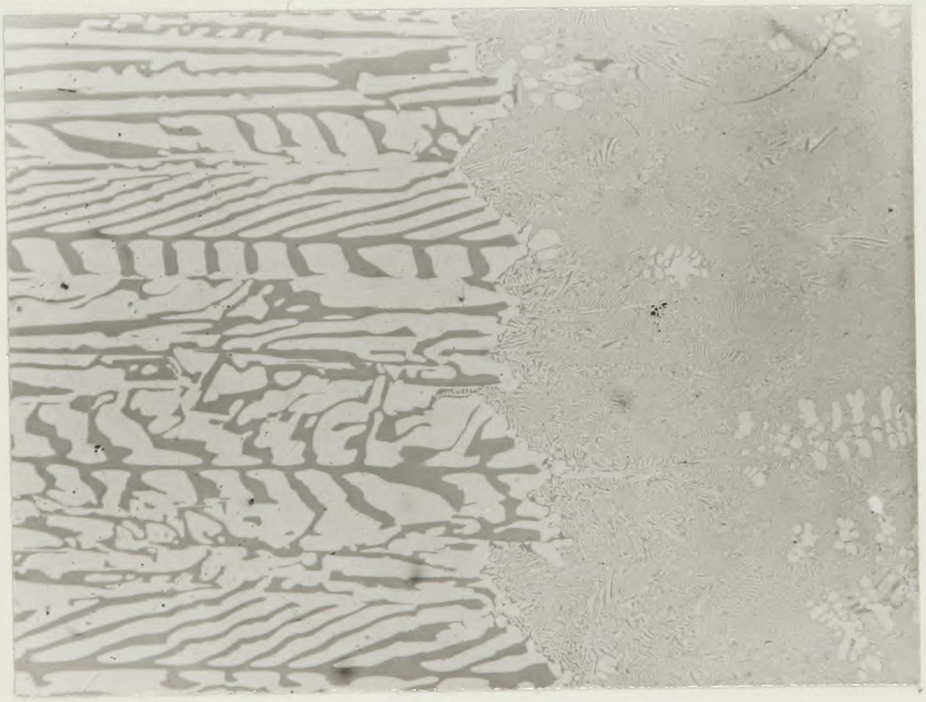


FIG. 122 Model of the Proposed Growth Front for a Complex Regular Eutectic Silicon Particle

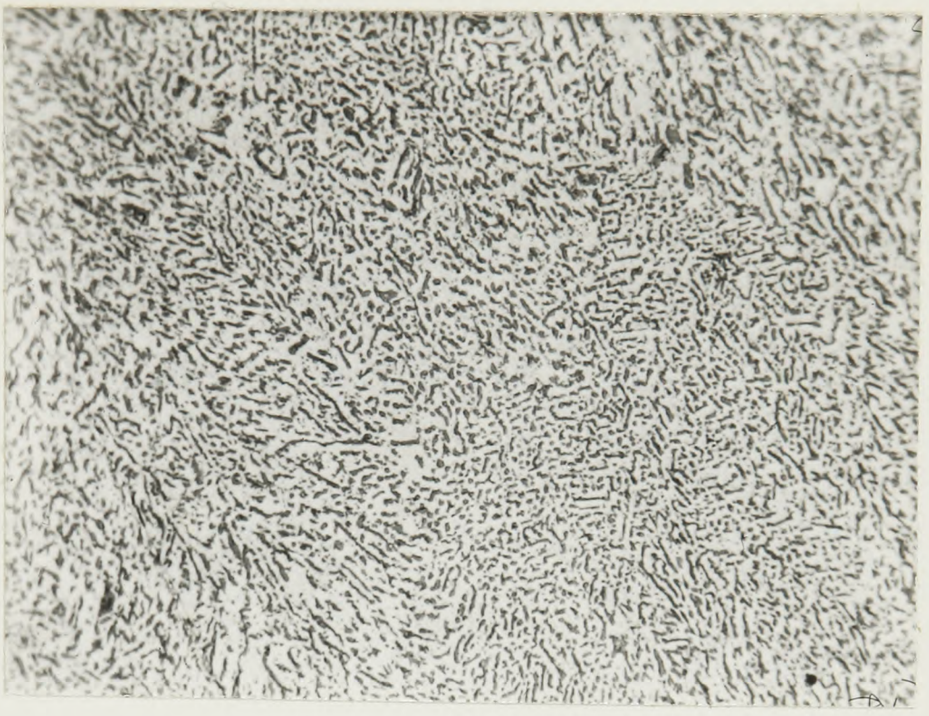


x 100

PLATE 122 A Quenched Al/Ge Web Interface
($R = 3 \times 10^{-5}$ cm/sec., $G = \sim 30^{\circ}C$/cm.)
(after Hellawell 1967a)

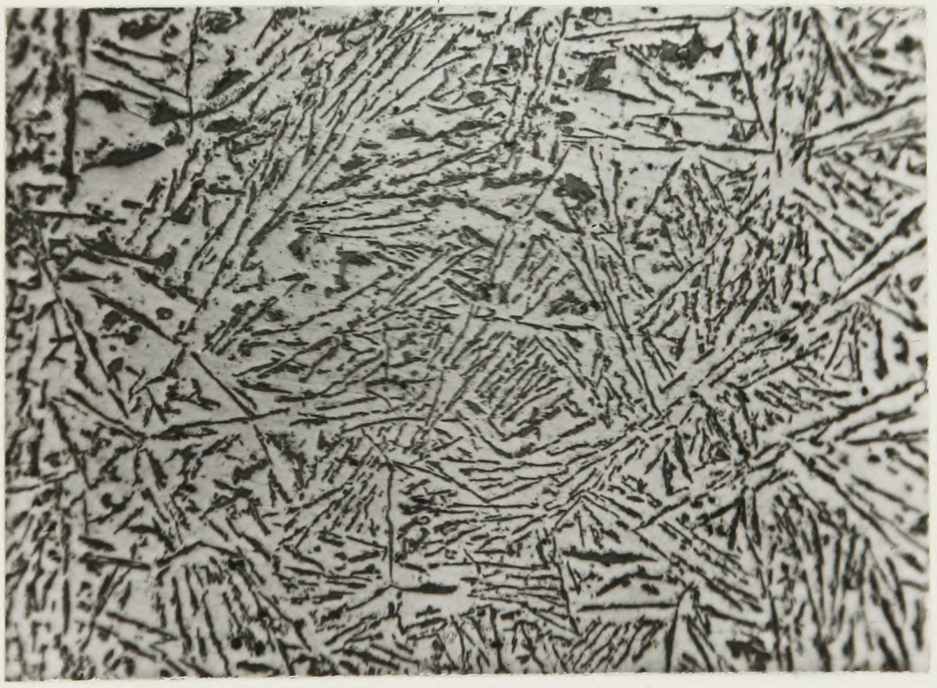
Eutectic alloy and growth conditions	Na concentration
Furnace cooled Al/Si eutectic	0.011 wt.%
" " Ag/Si eutectic	0.016 wt.%
" " Au/Si eutectic	0.092 wt.%
Al/Si eutectic R = 2.78×10^{-5} cm/sec, G = 29.5°C/cm	0.014 wt.%
Al/Si eutectic R = 1.37×10^{-3} cm/sec, G = 29.5°C/cm	0.009 wt.%

TABLE 123 - Sodium Concentration of Various Doped F.C.C. Metal/Silicon Eutectic Alloys.



x 460

PLATE 124a Sodium Modified Furnace-cooled Al/Si Eutectic



x 225

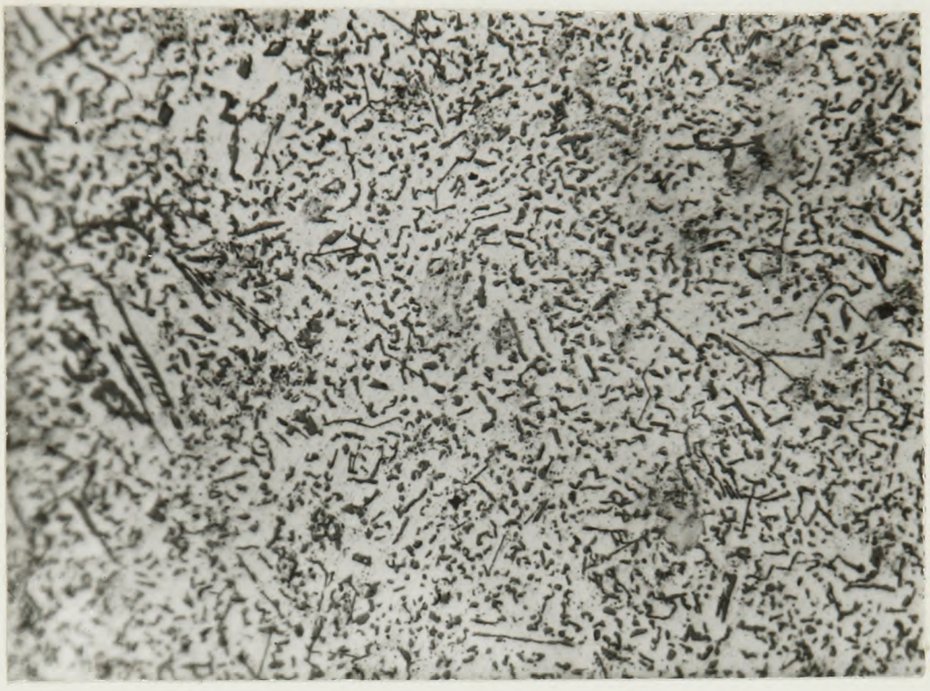
PLATE 124b Furnace-cooled Al/Si Eutectic

x 1,300

PLATE 125a Sodium Modified Furnace-cooled
Al/Si Eutectic
(heavily etched)

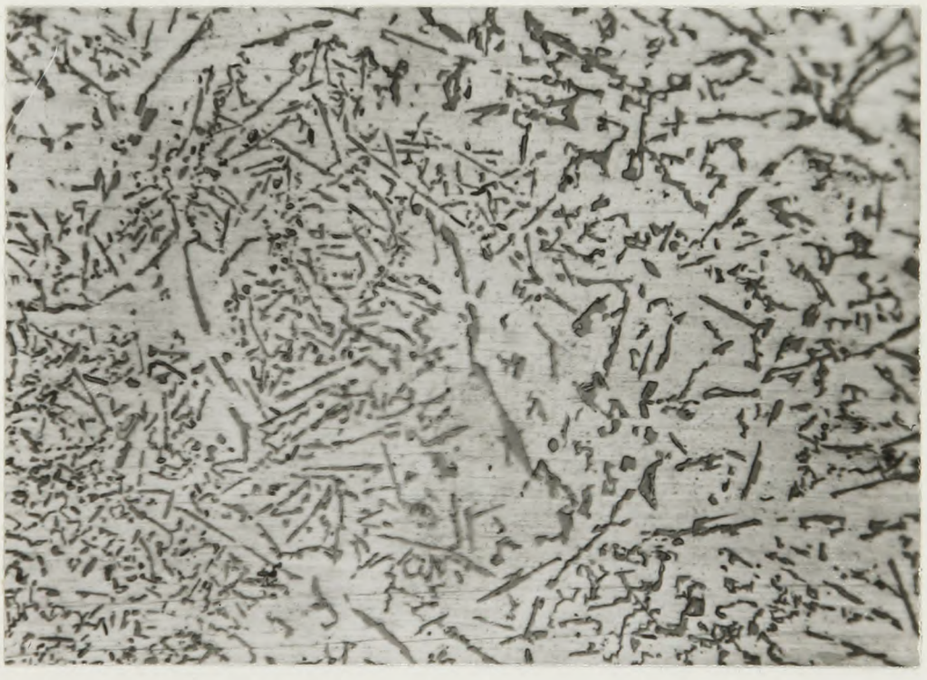
x 7,500

PLATE 125b Sodium Modified Furnace-cooled
Al/Si Eutectic
(heavily etched)



x 460

PLATE 126a Sodium Modified Furnace-cooled Ag/Si Eutectic

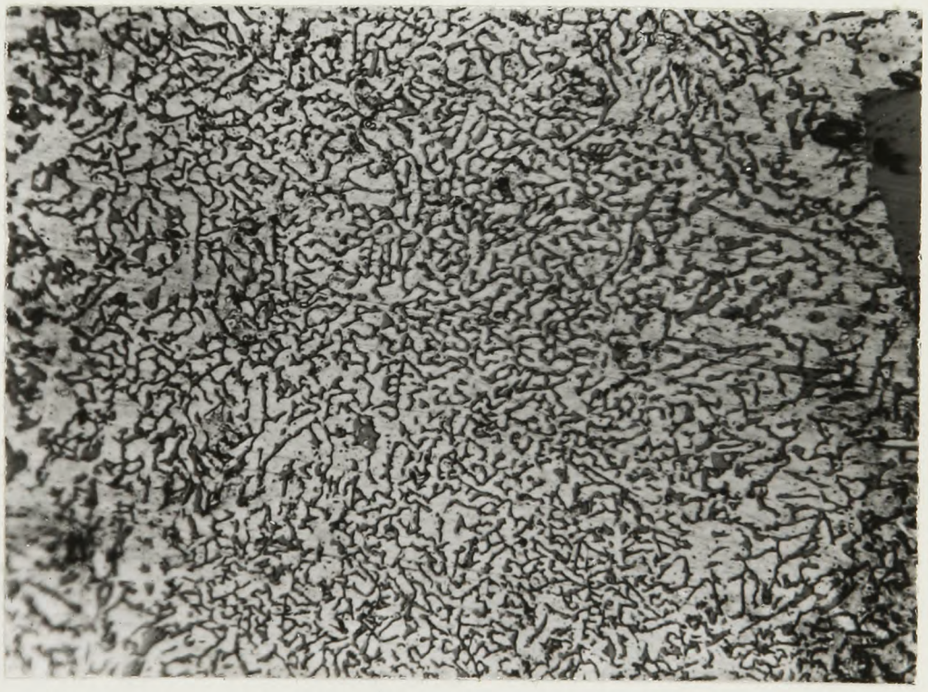


x 460

PLATE 126b Furnace-cooled Ag/Si Eutectic

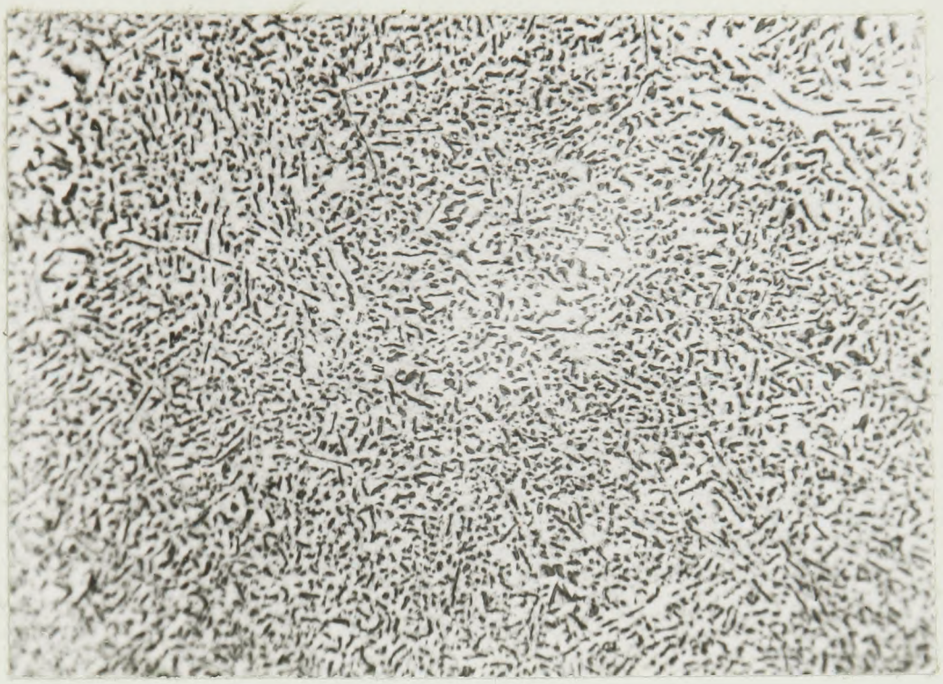
x 460

PLATE 127a Sodium Modified Furnace-cooled Au/Si Eutectic



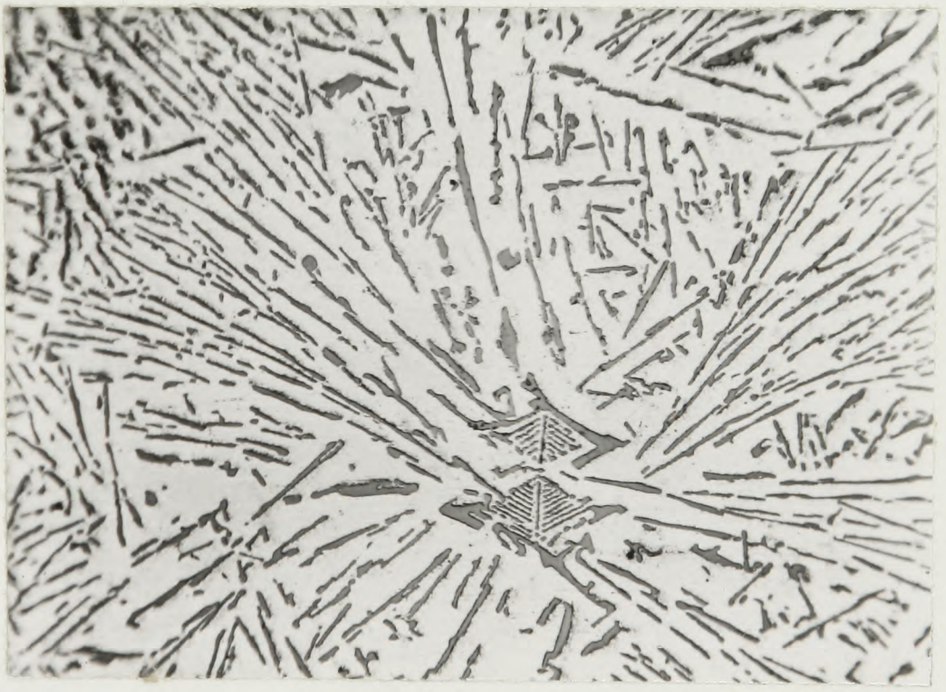
x 460

PLATE 127b Furnace-cooled Au/Si Eutectic



x 225

PLATE 128a Sodium Modified Al/Si Eutectic - transverse section
($R = 1.37 \times 10^{-3}$ cm/sec., $G = 29.5^{\circ}C$/cm.)



x 225

PLATE 128b Al/Si Eutectic - transverse section
($R = 1.37 \times 10^{-3}$ cm/sec., $G = 29.5^{\circ}C$/cm.)