POLITECHNIKA KRAKOWSKA

mgr inż. Zbigniew Wnęk

P R A C A D O K T O R S K A

TEMAT: "Wpływ procesu walcowania na wtrącenia niemetaliczne w stali transformatorowej"

PROMOTOR: Prof.dr h.inż. Stanisław Rudnik

A L B U M F O T O G R A F I I

K r a k ó w 1 9 7 9 r.

O p i s f o t o g r a f i i

Fot. 1 - 21. Ziarno blach badanych w Eksperymencie 1.
Numeracja odpowiednio do Tabeli 14, 15,16.
Reprodukcja x 2,2.

Fot. 22 - 42. Wtrącenia w blachach badanych w Eksperymencie 1.
Numeracja zdjęć odpowiednio do Tabeli 14.
Reprodukcja x 2,2. c.p. - ciemne pole

Fot.43. Dyfraktogram z izolatu wtrąceń niemetalicznych w wytopie eksperymentalnym.
Reprodukcja 1 : 1.

Fot. 44. Typowe wtrącenia w wytopie eksperymentalnym.

a, b - krzemiany żelazowe i żelazowo-manganowe sferoidalne

c, d - wtrącenia sferoidalne złożone krzemianowo-siarczkowe

e, f - krzemiany żelaza

g, h - wtrącenia złożone krzemianowo-siarczkowe

i, j - wtrącenia sferoidalne złożone krzemianowo-siarczkowe

Fot. 45. Nietypowe wtrącenia w wytopie eksperymentalnym.

a, b - krzemian osadzony na nie zidentyfikowanej cząstce

c, d - krzemian osadzony na azotku Al

e, f - krzemian osadzony na azotku Al

g - krzemiany, c.p.

h - azotki

Fot. 46. Wtrącenia sztuczne nr 1-5 /por. Tabela 20, 21/ po przewalcowaniu przy temperaturze 1000°C w osnowie stali krzemowej.
Reprodukcja x 1,2.

Fot. 47. Wtrącenia sztuczne nr 1-5 /por. Tabela 20, 21/ po przewalcowaniu przy temperaturze 1100°C w osnowie stali krzemowej.
Reprodukcja x 1,2.

Fot. 48. Wtrącenia sztuczne nr 1-5 /por. Tabela 20, 21/ po przewalcowaniu przy temperaturze 1200°C w osnowie stali krzemowej.
Reprodukcja x 1,2.

Fot. 49. Wtrącenia sztuczne nr 1-5 /por. Tabela 20, 21/ po przewalcowaniu przy temperaturze 1250°C w osnowie stali krzemowej.
Reprodukcja x 1,2.

Fot. 50. Wtrącenia sztuczne nr 1-5 /por. Tabela 20, 21/ po przewalcowaniu przy temperaturze 1300°C w osnowie stali krzemowej.
Reprodukcja x 1,2.

Fot. 51. Wtrącenia sztuczne nr 1, próbki M /por. Tabela 20, 21/ po przewalcowaniu przy temperaturze 1100, 1200°C w osnowie stali węglowej.
Reprodukcja x 1,2.

Fot. 52. Wtrącenia sztuczne nr 1, próbki M /por. Tabela 20, 21/ po przewalcowaniu przy temperaturze 1200, 1300°C w osnowie stali węglowej.
Reprodukcja x 1,2.

Fot. 53. Wtrącenia sztuczne nr 3, próbki F /por. Tabela 20, 21/ po przewalcowaniu przy temperaturze 1100, 1300°C w osnowie stali węglowej.
Reprodukcja x 1,2.

Fot. 54 a-e. Przykłady niestabilnego odkształcenia wtrąceń sztucznych "T" /stal krzemowa/.
Oznaczenia wg Tabeli 21.
Reprodukcja x 2,2.

Fot. 55 a-e. Przykłady niestabilnego odkształcenia wtrąceń sztucznych "M", "F" /stal węglowa/.
Oznaczenia wg Tabeli 21.
Reprodukcja x 2,2.

Fot.56 a-g. Wtrącenia sztuczne nr 1 /por. Tabela 20/ walcowane w osnowie stali krzemowej z różnym gniotem /Tabela 22/.
Reprodukcja x 2,2.

Fot. 57 a-e. Wtrącenia sztuczne nr 2 /por. Tabela 20/ walcowane w osnowie stali krzemowej z różnym gniotem /Tabela 22/.
Reprodukcja x 2,2.

Fot. 58 a-g. Wtrącenia sztuczne nr 3 /por.Tabela 20/ walcowane w osnowie stali krzemowej z różnym gniotem /Tabela 22/.
Reprodukcja x 2,2.

Fot. 59 a-e. Wtrącenia sztuczne nr 4 /por. Tabela 20/ walcowane w osnowie stali krzemowej z różnym gniotem /Tabela 22/.
Reprodukcja x 2,2.

Fot. 60 a-b. Wtrącenia sztuczne nr 5 /por. Tabela 20/ walcowane w osnowie stali krzemowej z różnym gniotem /Tabela 22/.
Reprodukcja x 2,2.

Fot. 61 a-c. Ziarno blach uzyskanych w próbach A, B, C /Eksperyment 3/. Por. punkt 7.7.3.1.

Fot. 62 a-j. Wtrącenia w blachach A /Eksperyment 3/.
Obserwacje w jasnym i ciemnym polu.
a - f: po walcowaniu na gorąco
g - j: gotowa blacha po wyżarzeniu
Reprodukcja x 2,2.

Fot. 63 a-j. Wtrącenia w blachach B /Eksperyment 3/.
Obserwacje w jasnym i ciemnym polu.
a - f: po walcowaniu na gorąco
g - j: gotowa blacha po wyżarzeniu
Reprodukcja x 2,2.

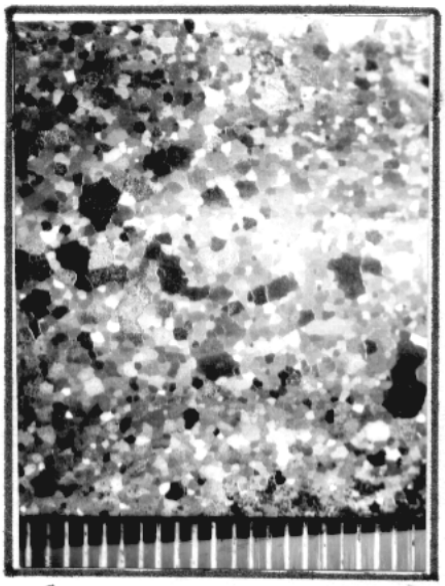
Fot. 64 a-j. Wtrącenia w blachach C /Eksperyment 3/.
Obserwacje w jasnym i ciemnym polu.
a - f: po walcowaniu na gorąco
g - j: gotowa blacha po wyżarzeniu
Reprodukcja x 2,2.

Fot. 65 a-f. Wtrącenia w blachach A /Eksperyment 3/.
Obserwacje z mikroskopu elektronowego
/repliki węglowe/.
a - b: siarczki
c - f: krzemiany
Reprodukcja 1:1.

Fot. 66 a-d. Wtrącenia w blachach B /Eksperyment 3/.
Obserwacje z mikroskopu elektronowego
/folie i repliki węglowe/.
a - b: siarczki
c - d: krzemiany
Reprodukcja 1:1.

Fot. 67 a-f. Wtrącenia w blachach C /Eksperyment 3/.
Obserwacje z mikroskopu elektronowego
/folie i repliki węglowe/.
a - b: siarczki
c - d : krzemiany
e - f: krzemionka
Reprodukcja 1:1.

FOT. 1–21



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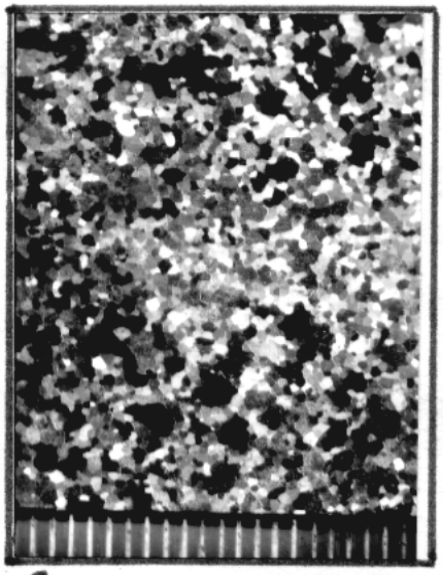

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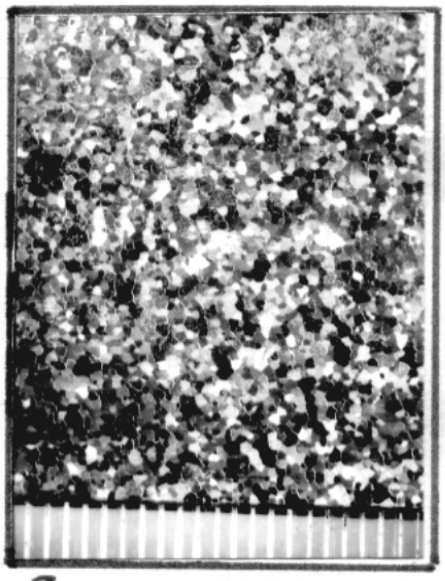

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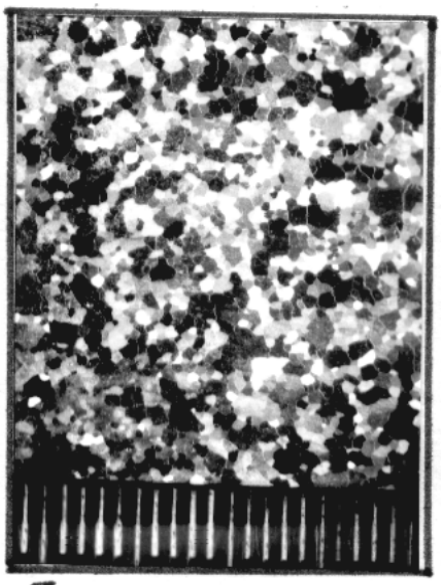

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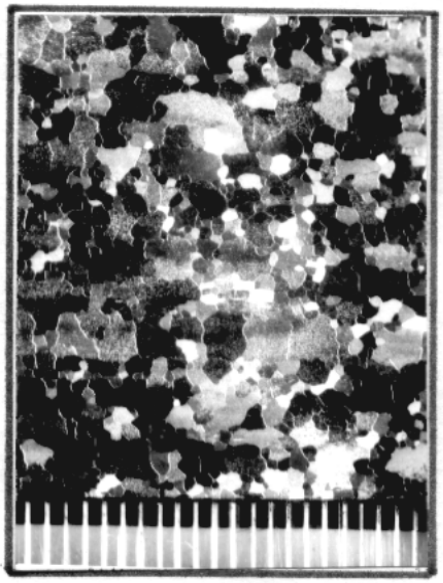

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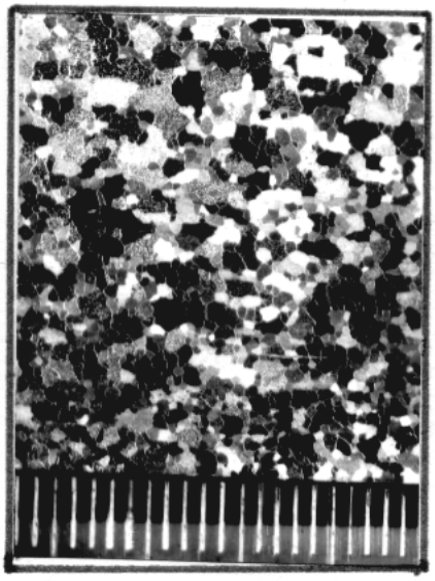

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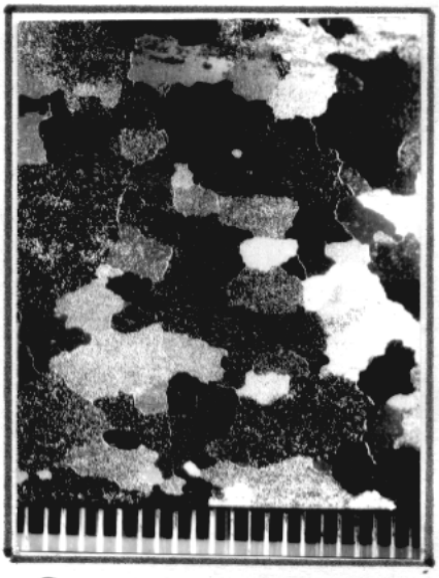

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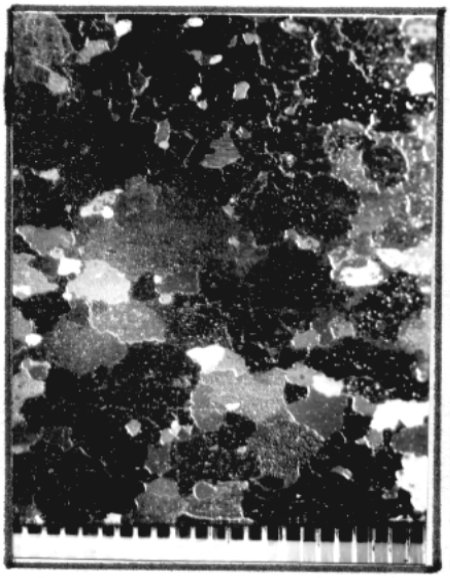

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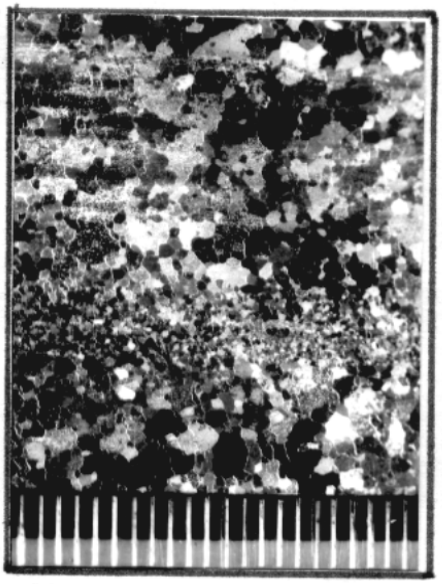

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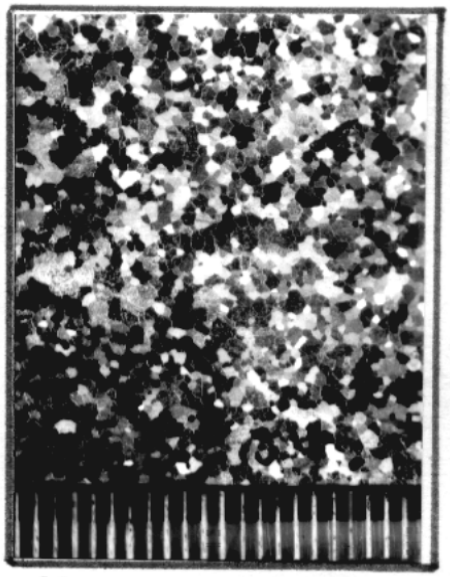

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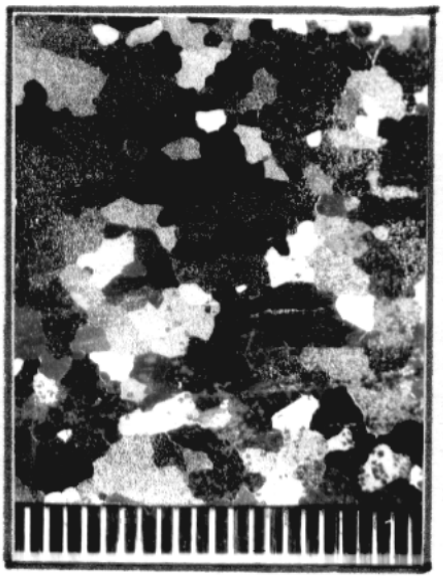

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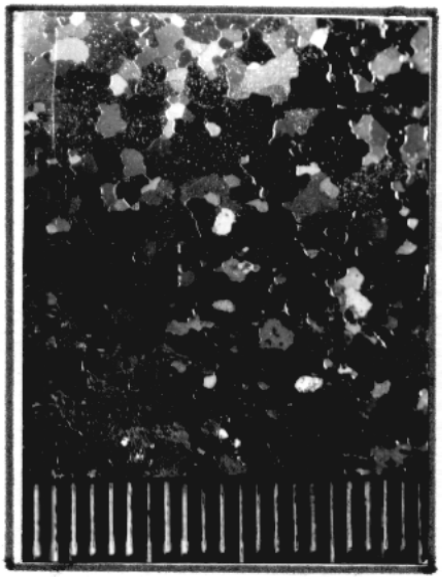

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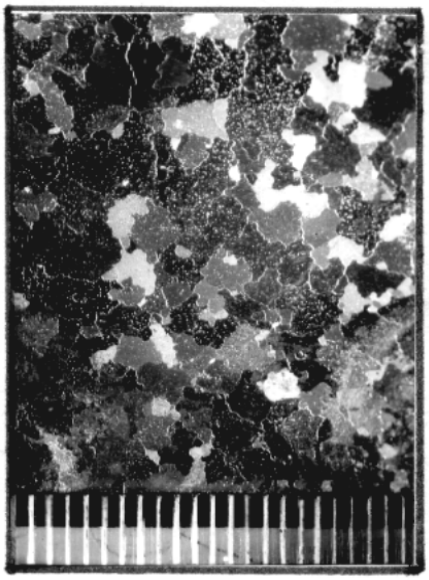

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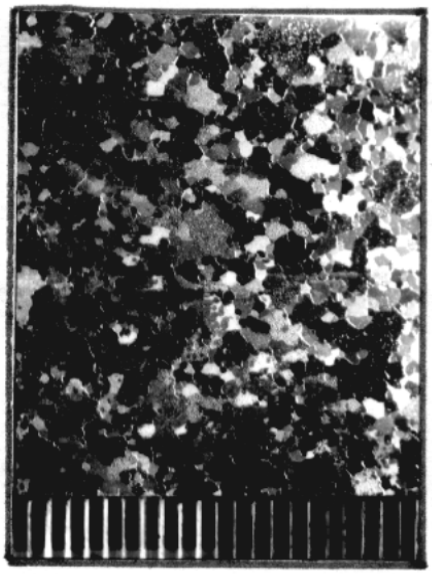

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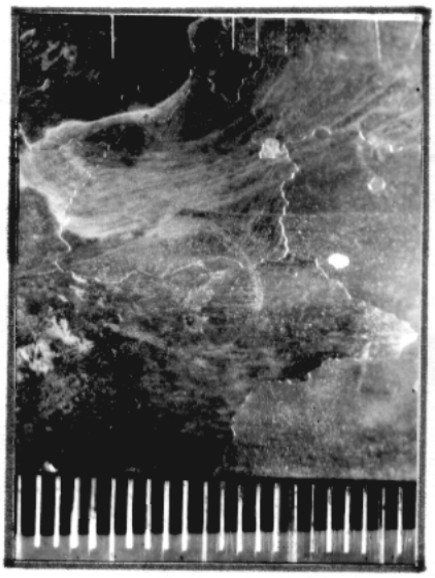

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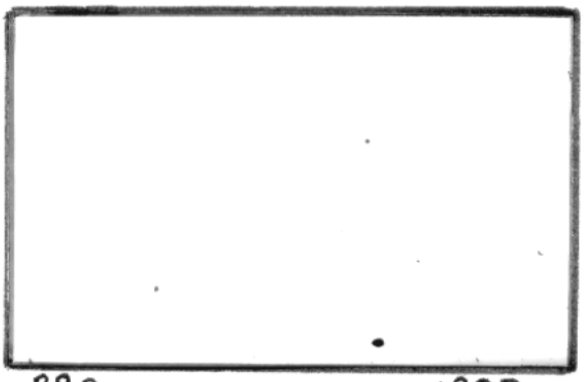
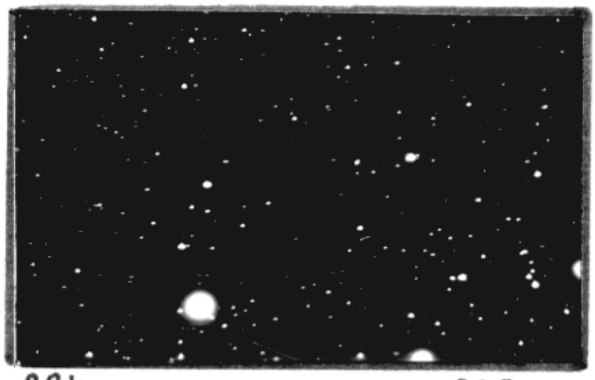
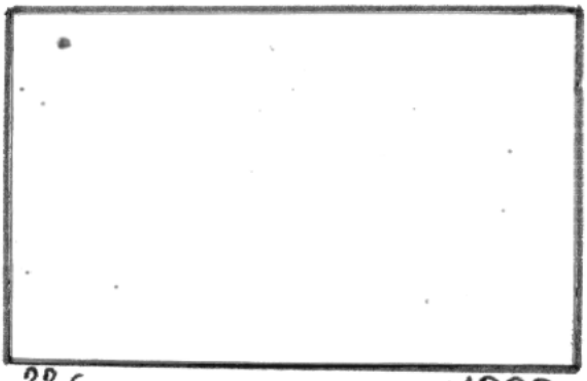
FOT. 22-42



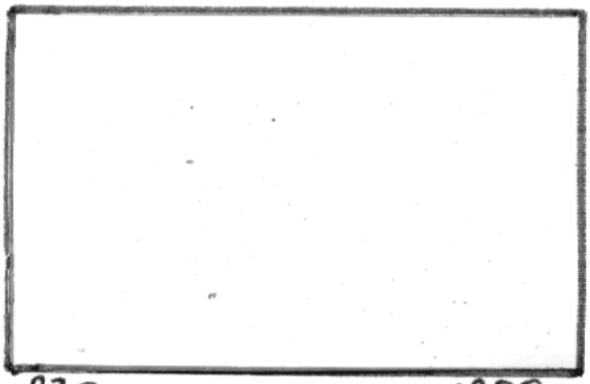
22a ×200



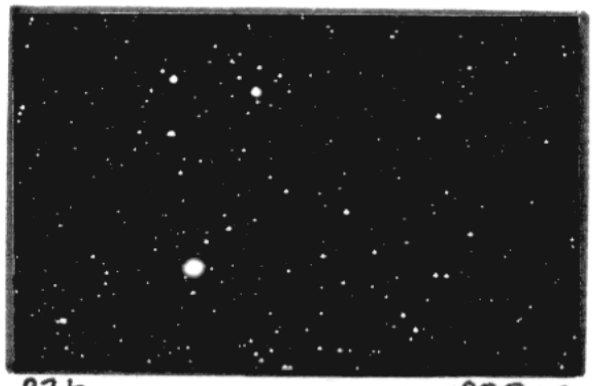
22b ×200 c.p.



22c ×1000



23a ×200



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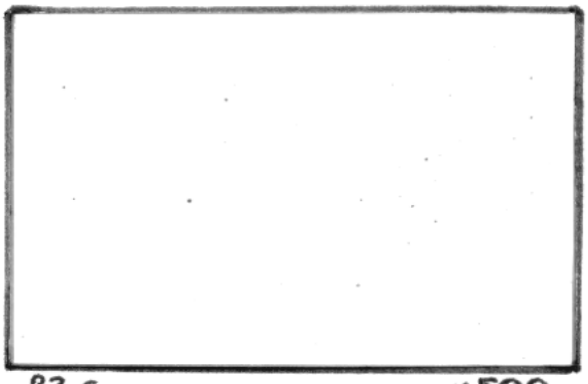

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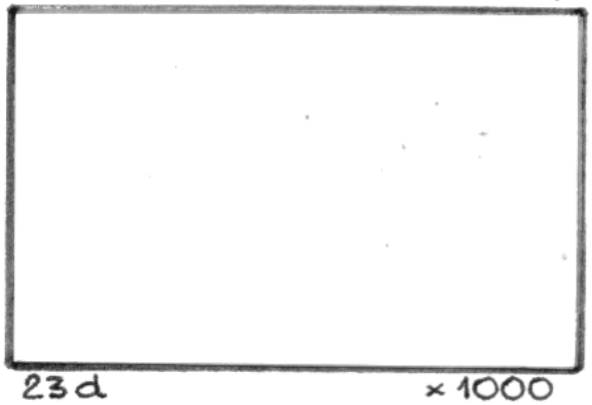
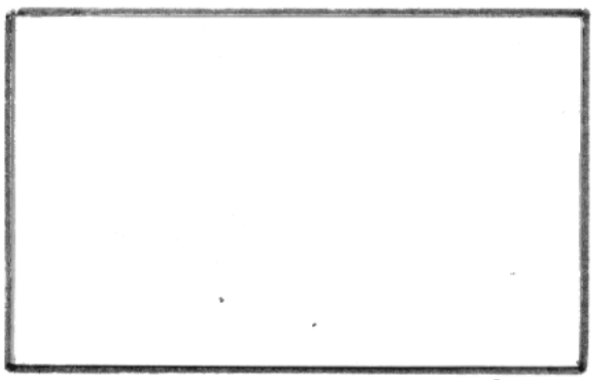


23d ×1000



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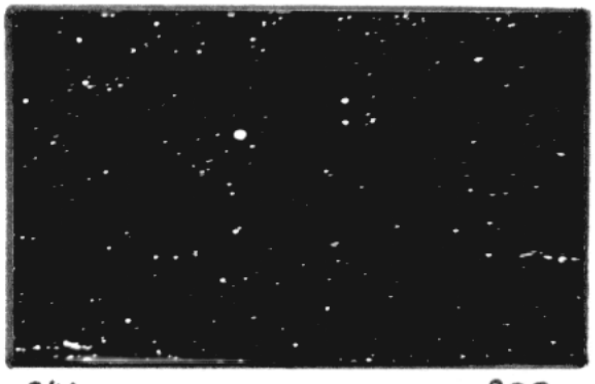

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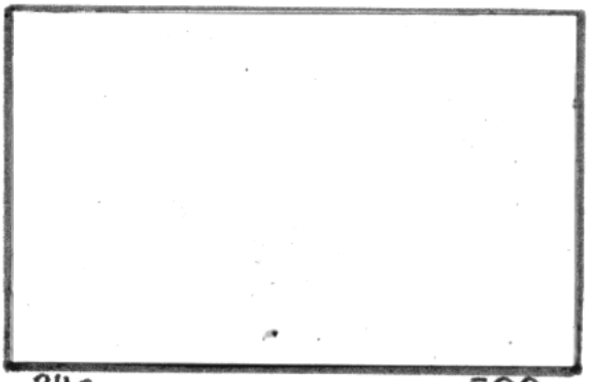

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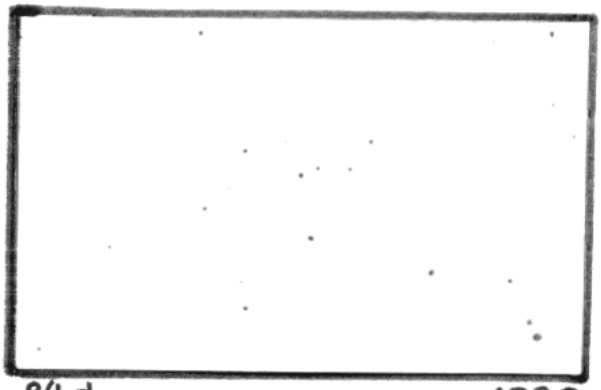

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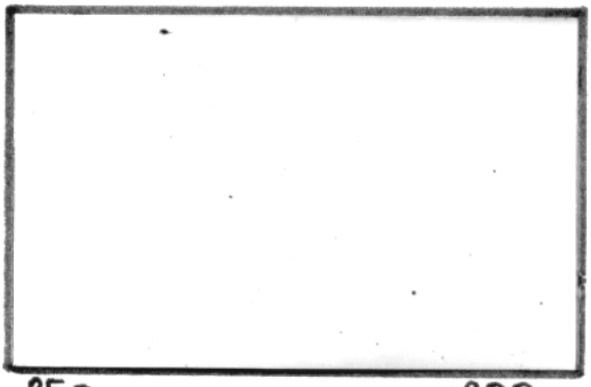

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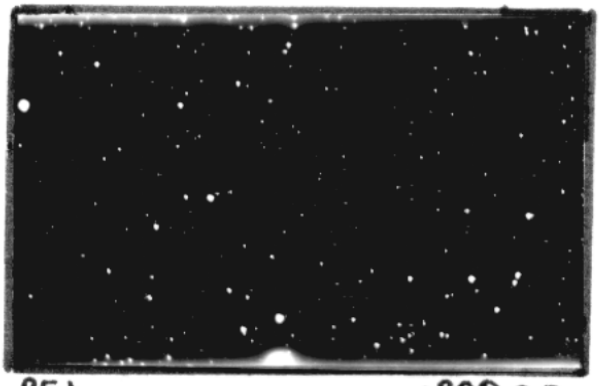

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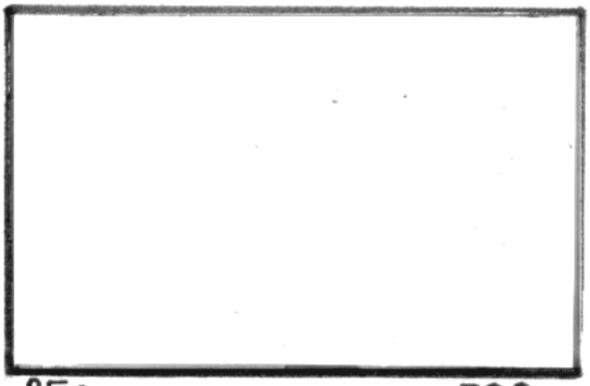

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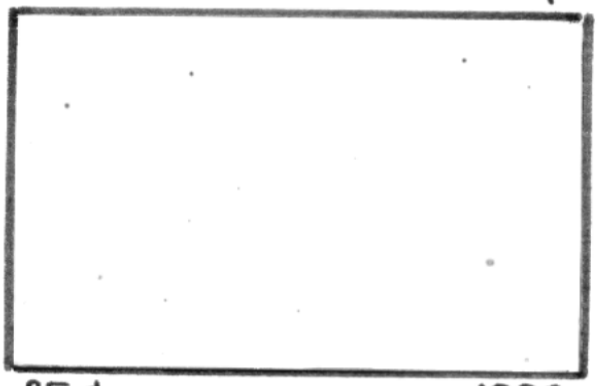

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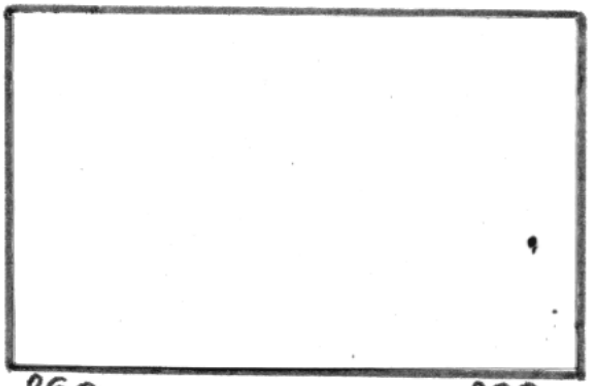

26a ×200

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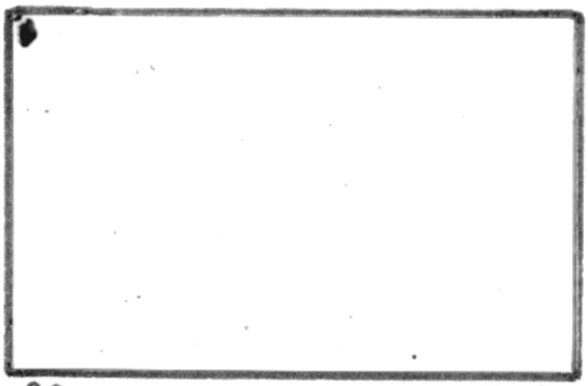

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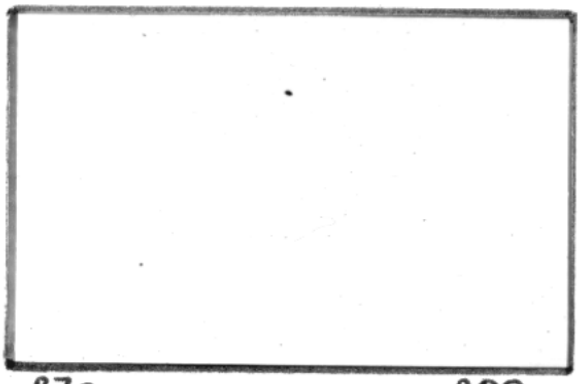

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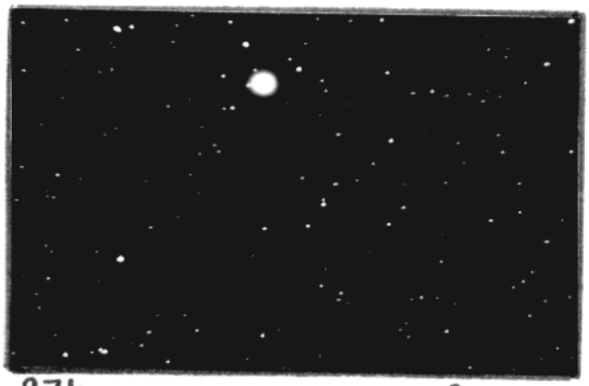

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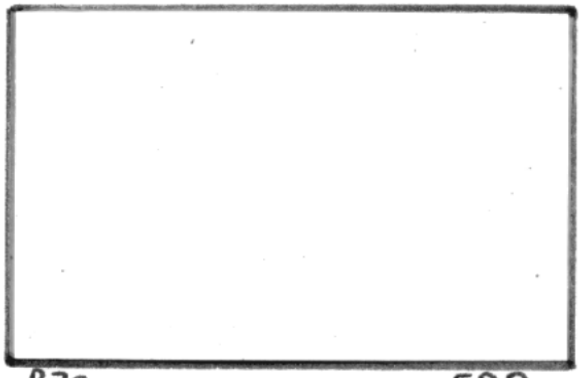

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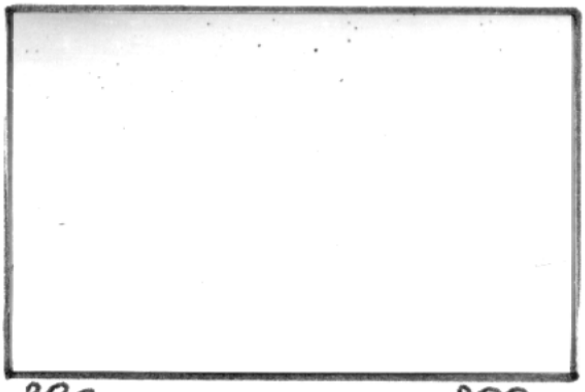

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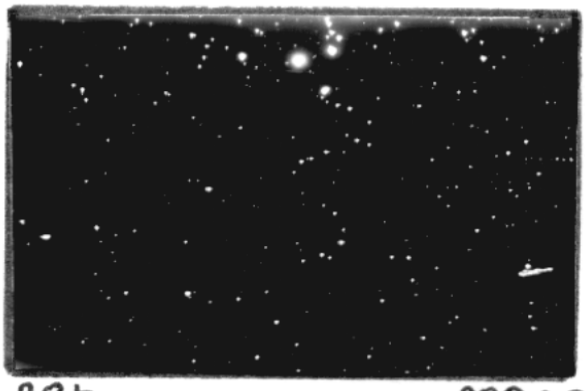

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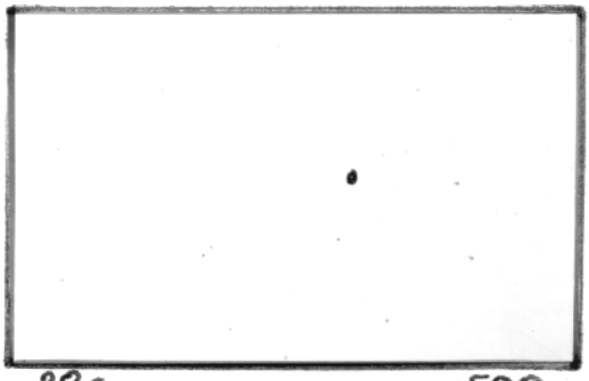

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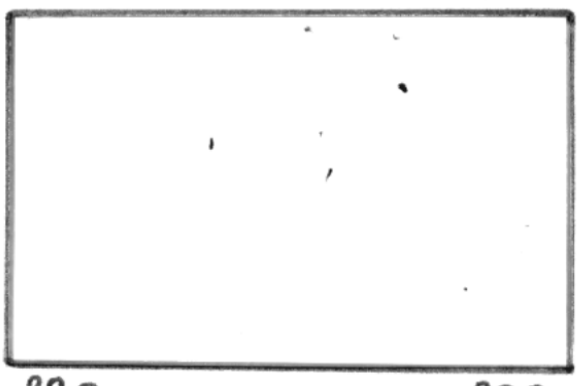

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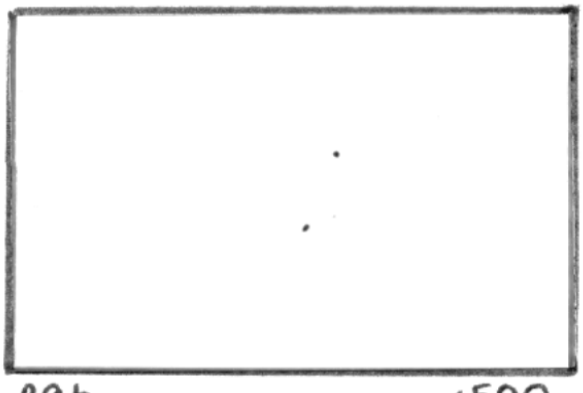

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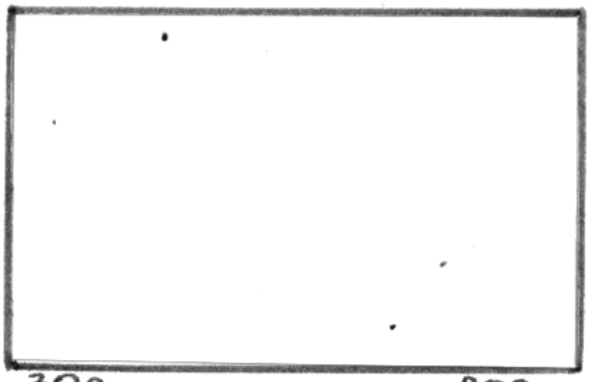

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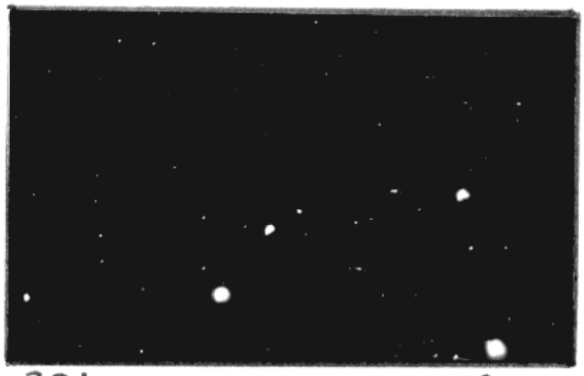

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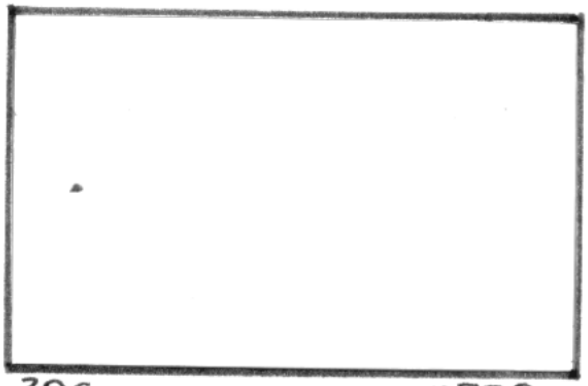
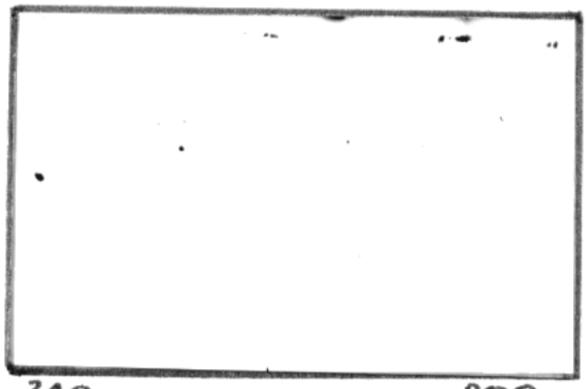
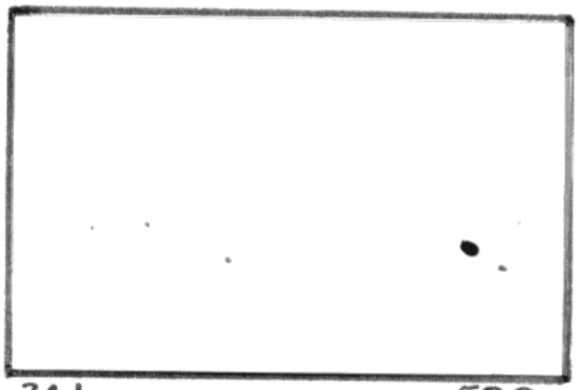


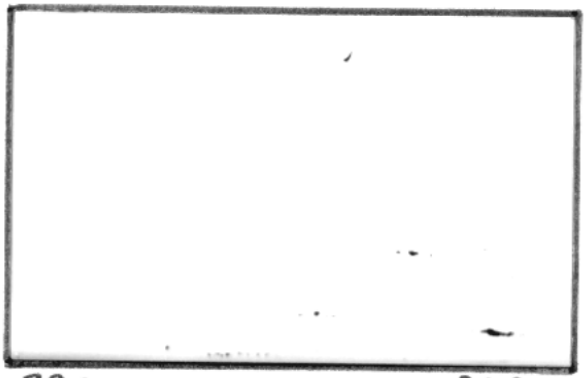
30c ×500



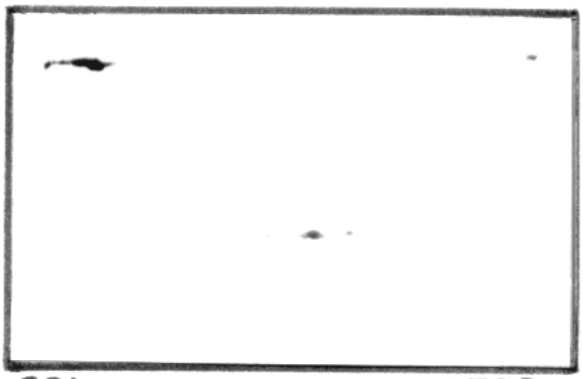
31a ×200



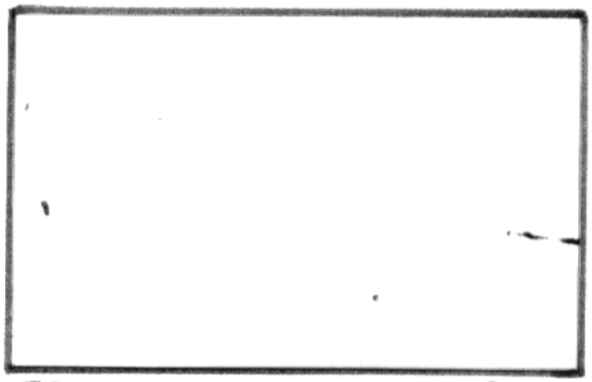
31b ×500



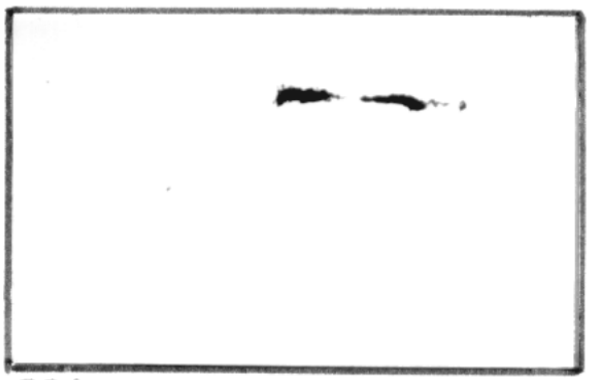
32a ×200



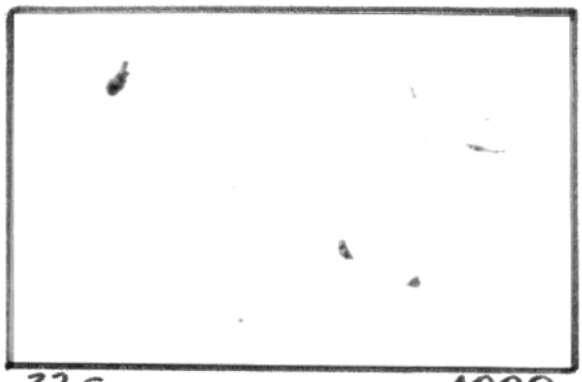
32b ×500



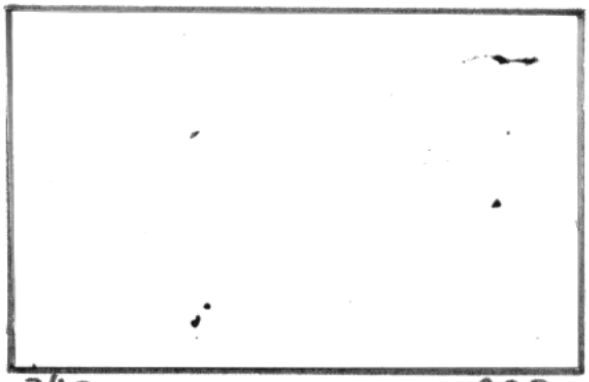
33a ×200



33b ×500

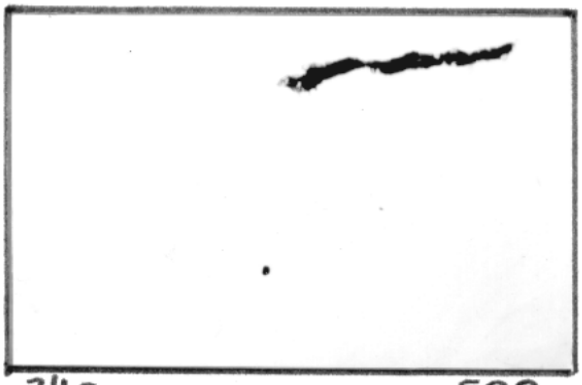


33c × 1000

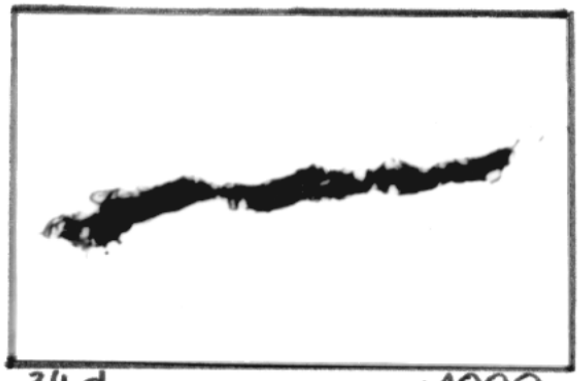


34a × 200

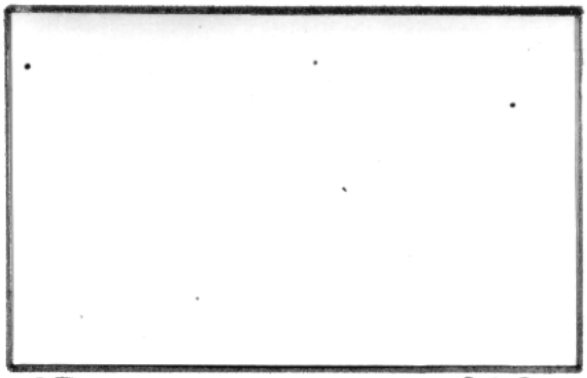
34b × 200 c.p.



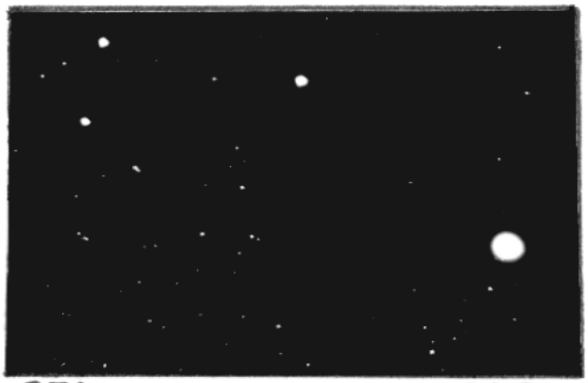
34c × 500



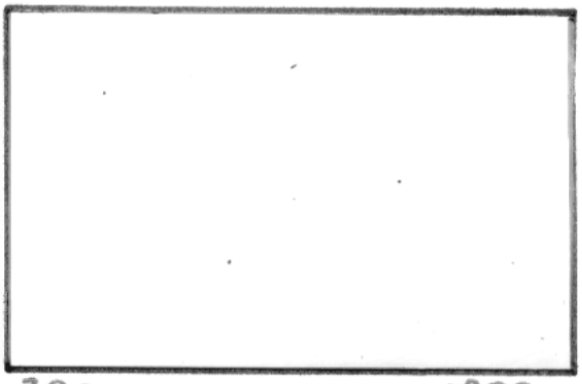
34d × 1000



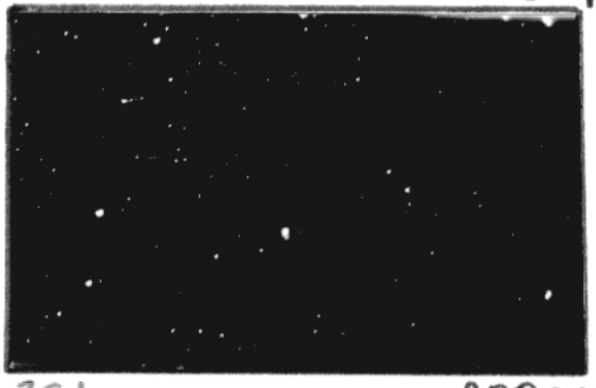
35a × 200



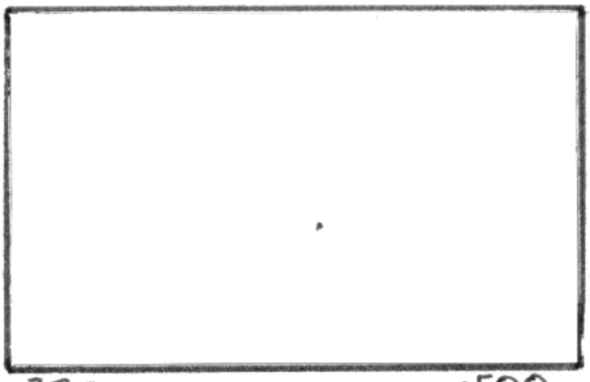
35b × 200 c.p.



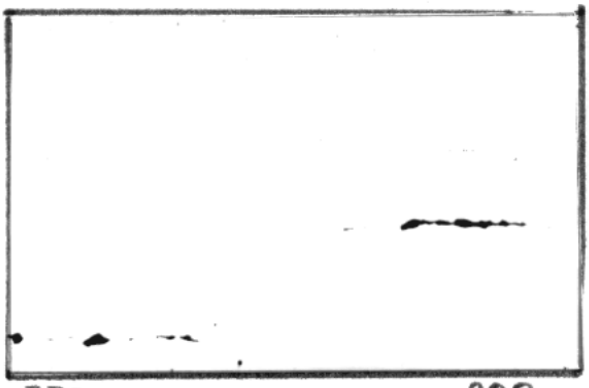
36a × 200



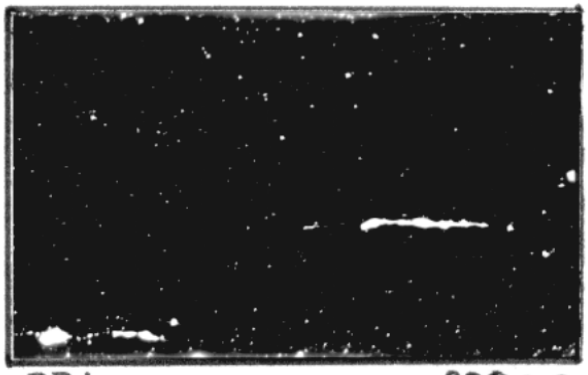
36b × 200 c.p.



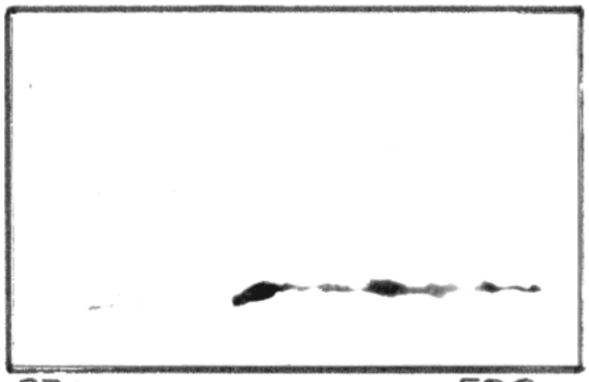
36 c ×500



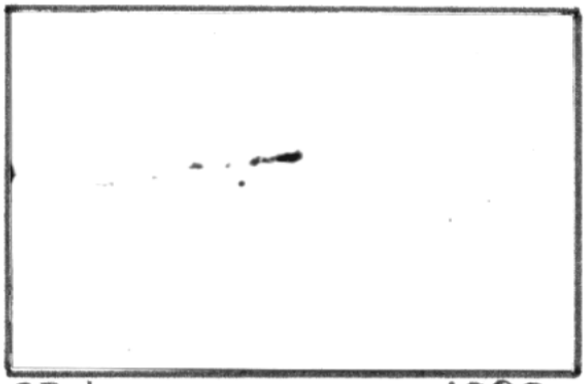
37a ×200



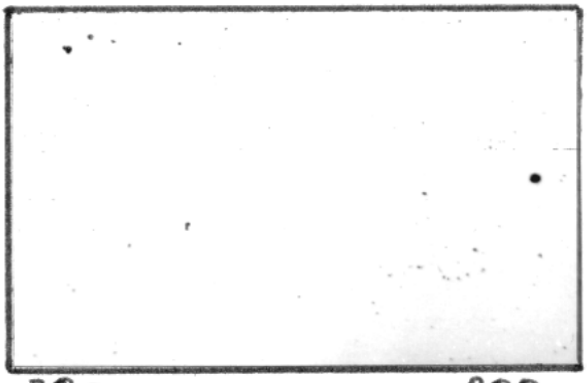
37 b ×200 c.p.



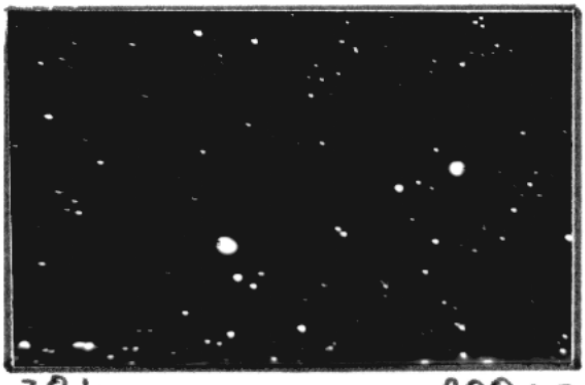
37c ×500



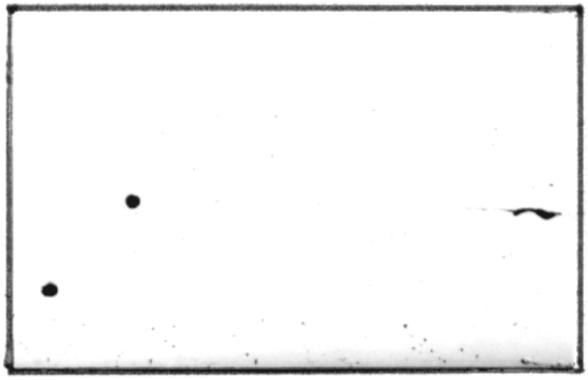
37 d ×1000



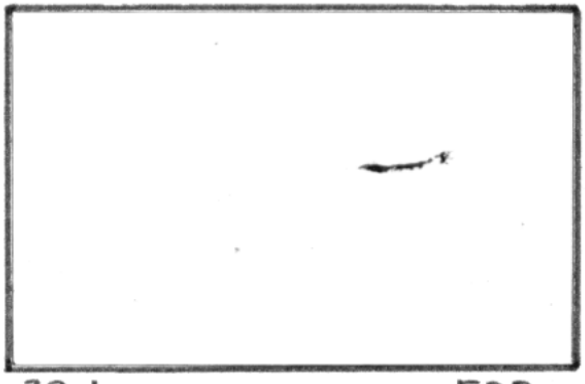
38 a ×200



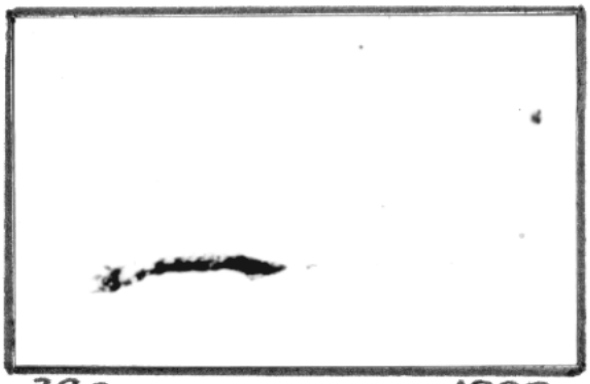
38 b ×200 c.p.



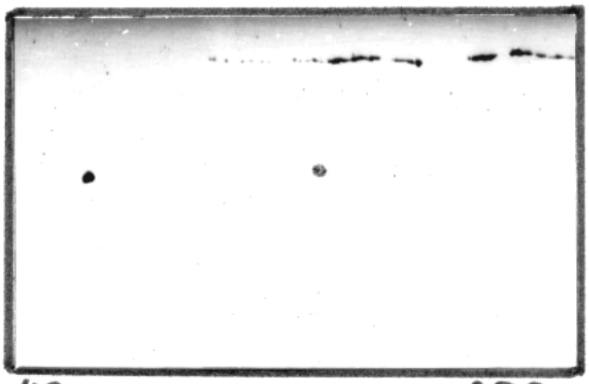
39 a ×200



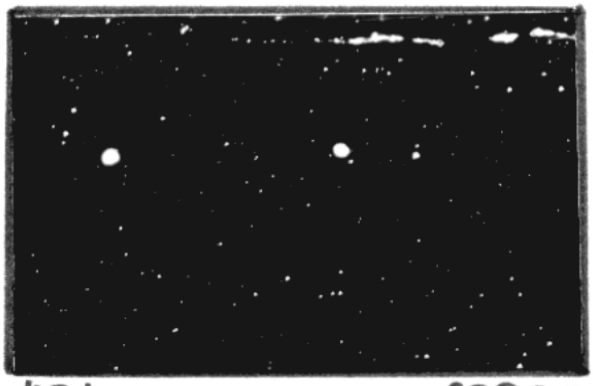
39 b ×500



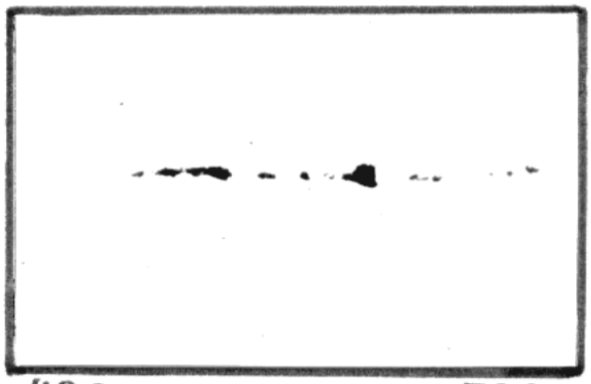
39c ×1000



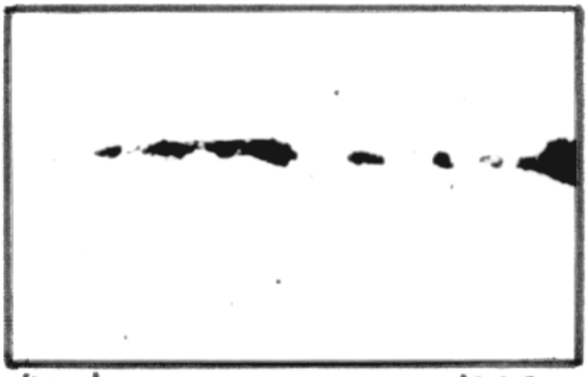
40a ×200



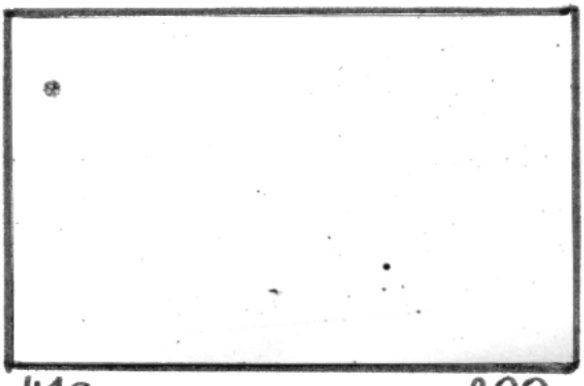
40b ×200 c.p.



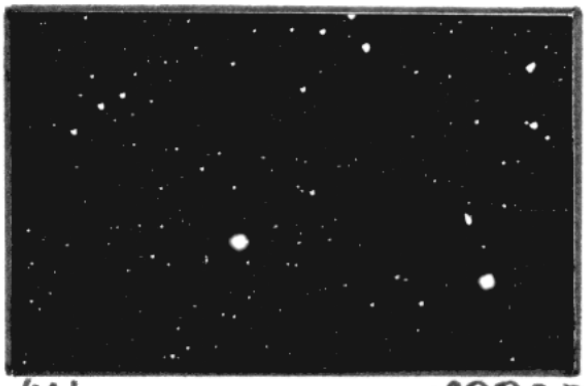
40c ×500



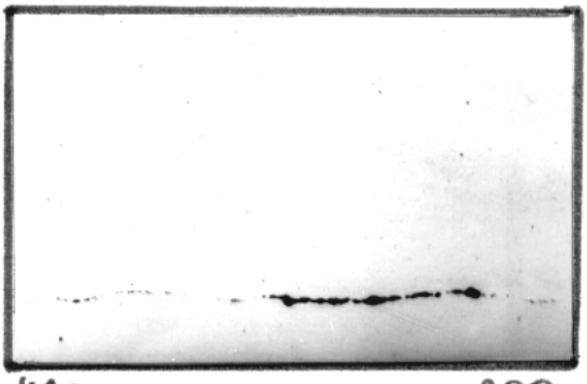
40d ×1000



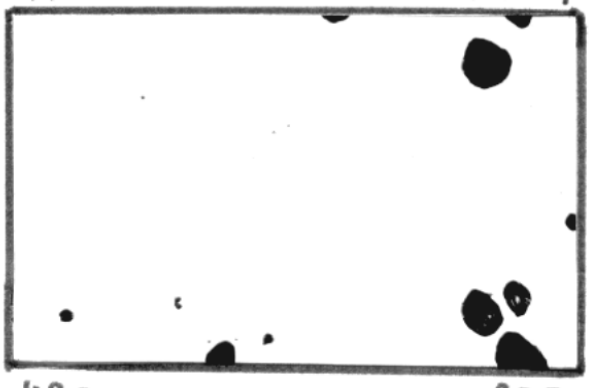
41a ×200



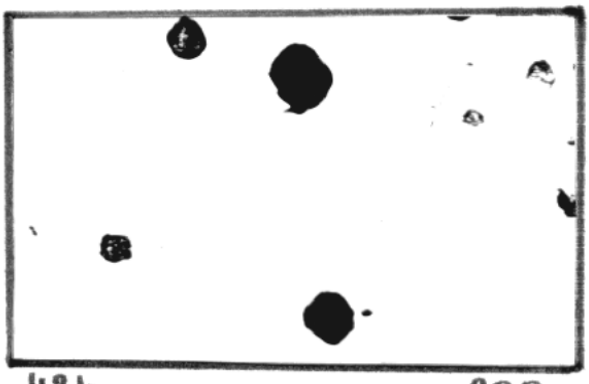
41b ×200 c.p.



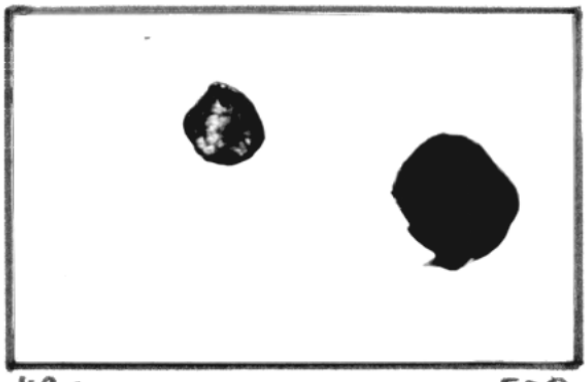
41c ×200



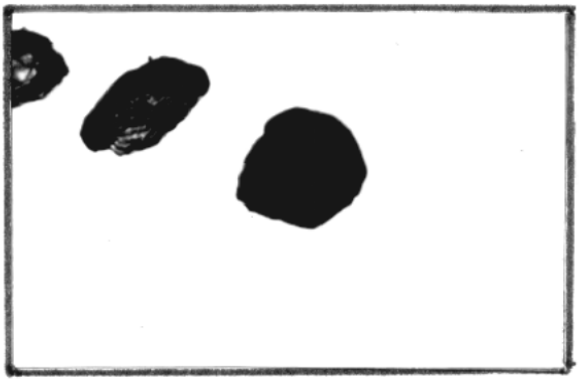
42a ×200



42b ×200

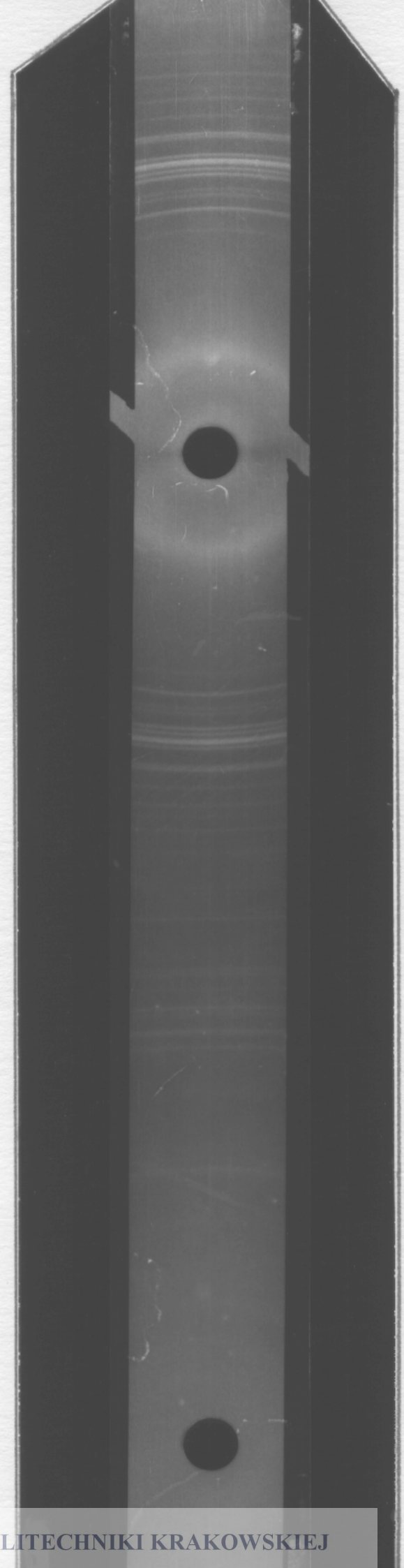


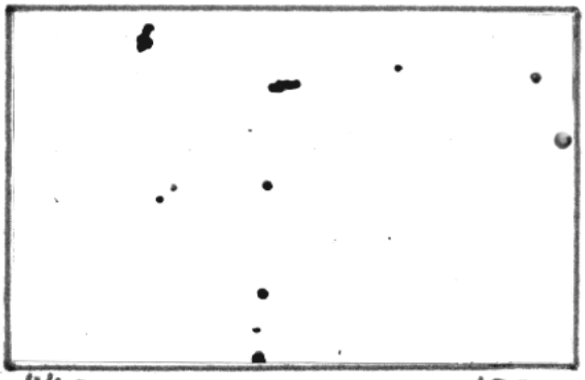
42c ×500



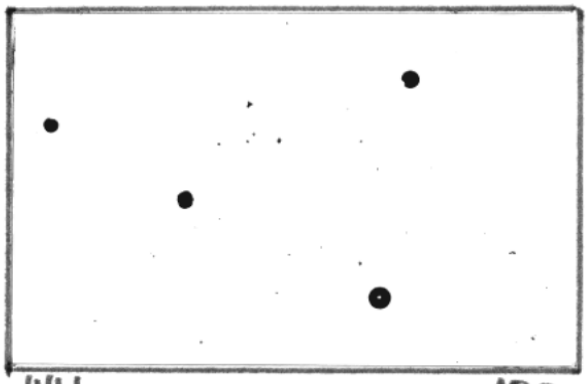
42d ×500

FOT. 43

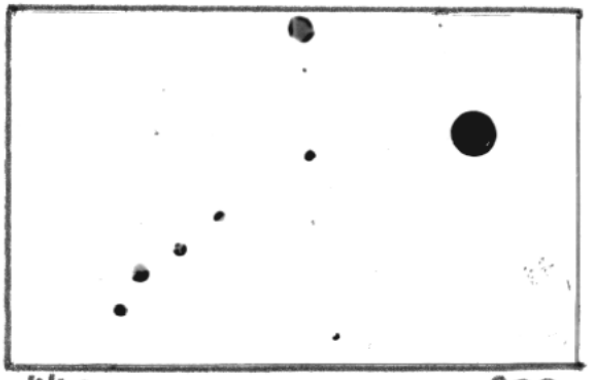




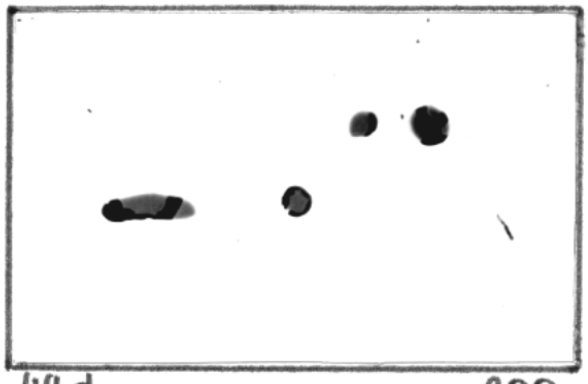
44a × 100



44b × 100

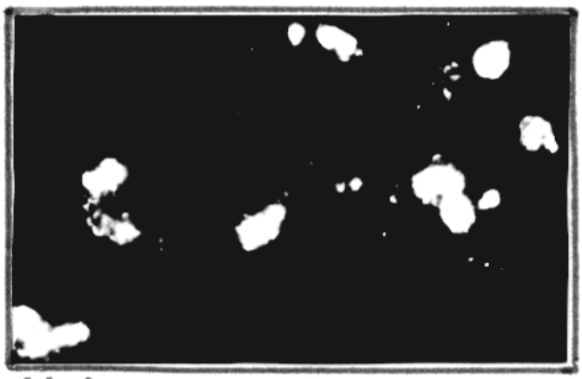


44c × 200



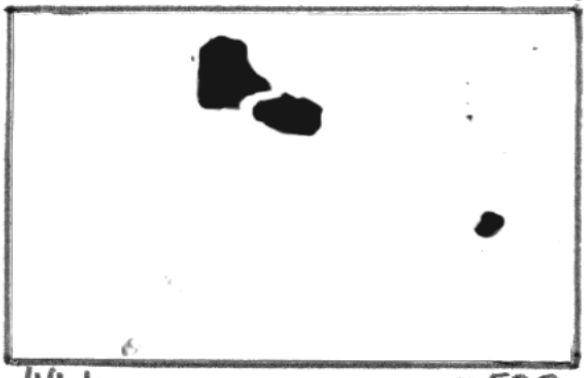
44d × 200

44e × 500

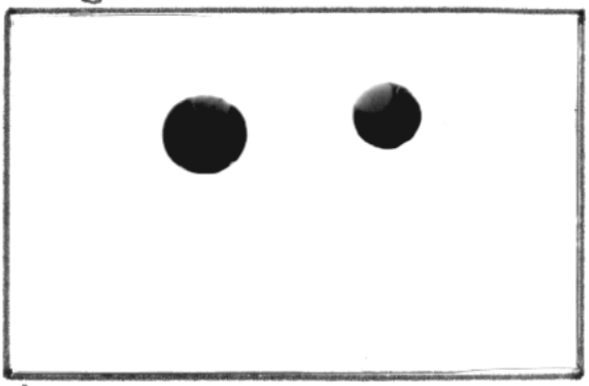


44f × 500 c.p.

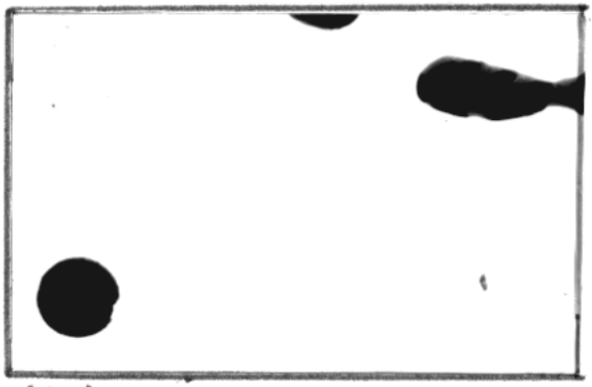
44g × 500



44h × 500

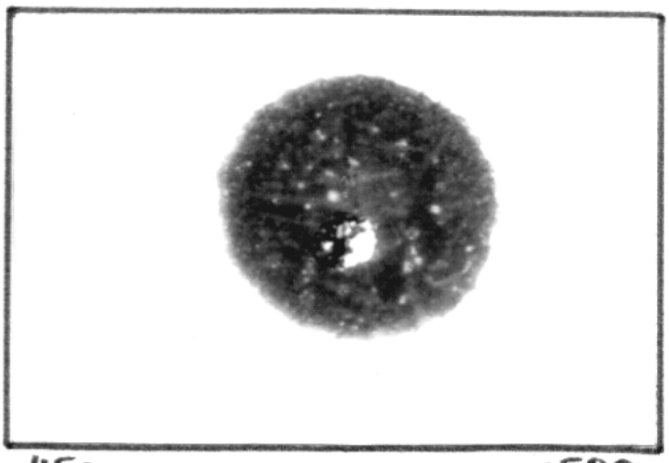


44i × 500

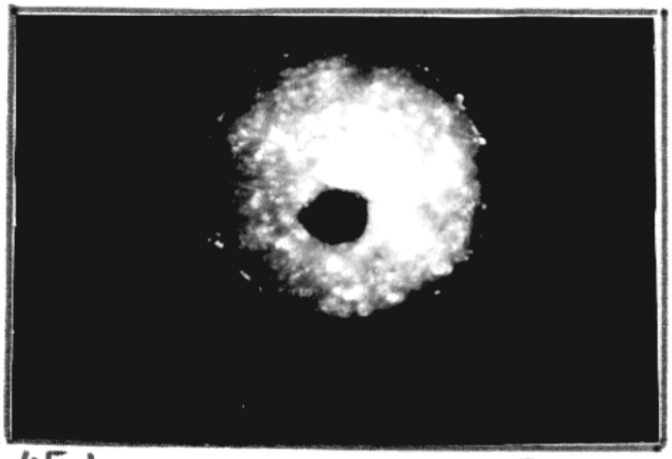


44j × 500

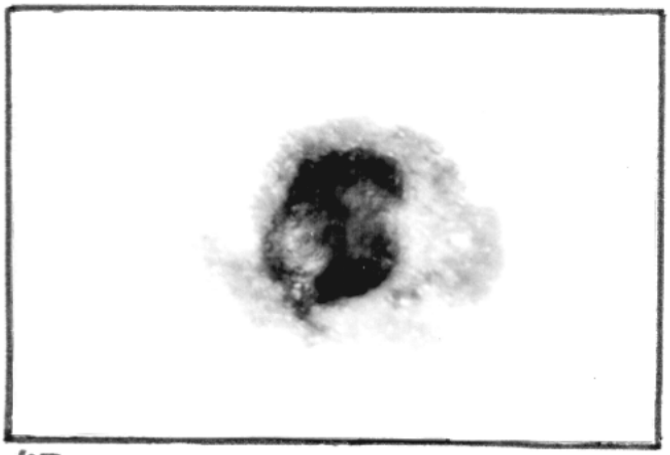
FOT. 45



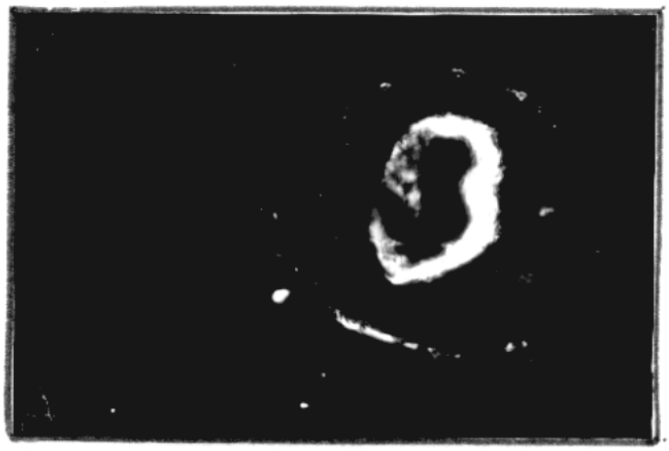
45a ×500



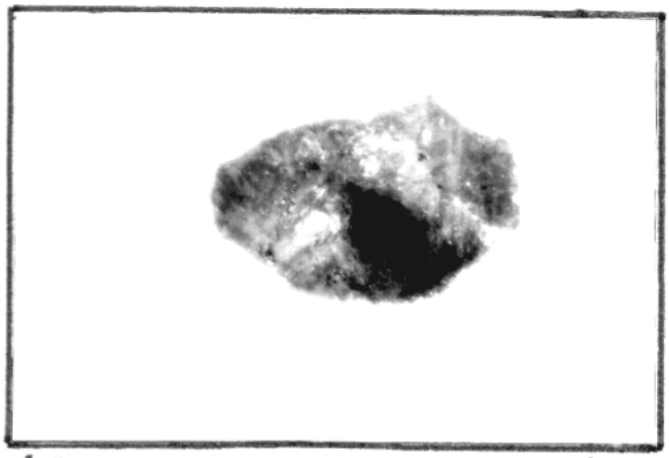
45 b ×500 c.p.



45c ×500

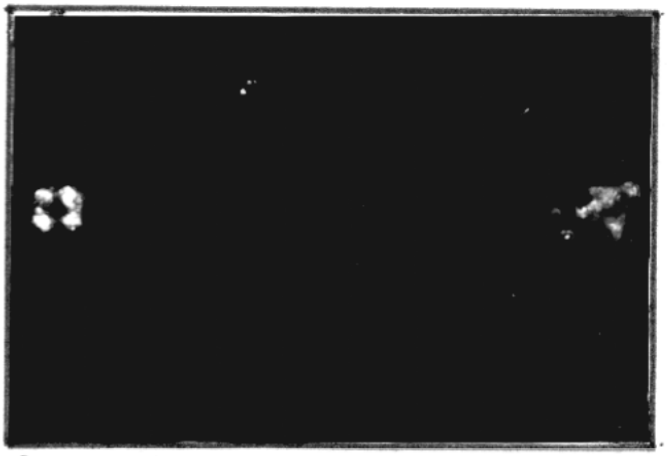


45 d ×500 c.p.

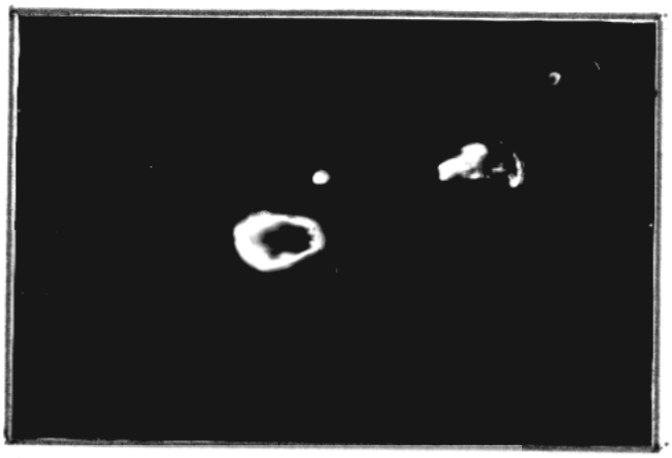


45 e ×500

45 f ×500 c.p.

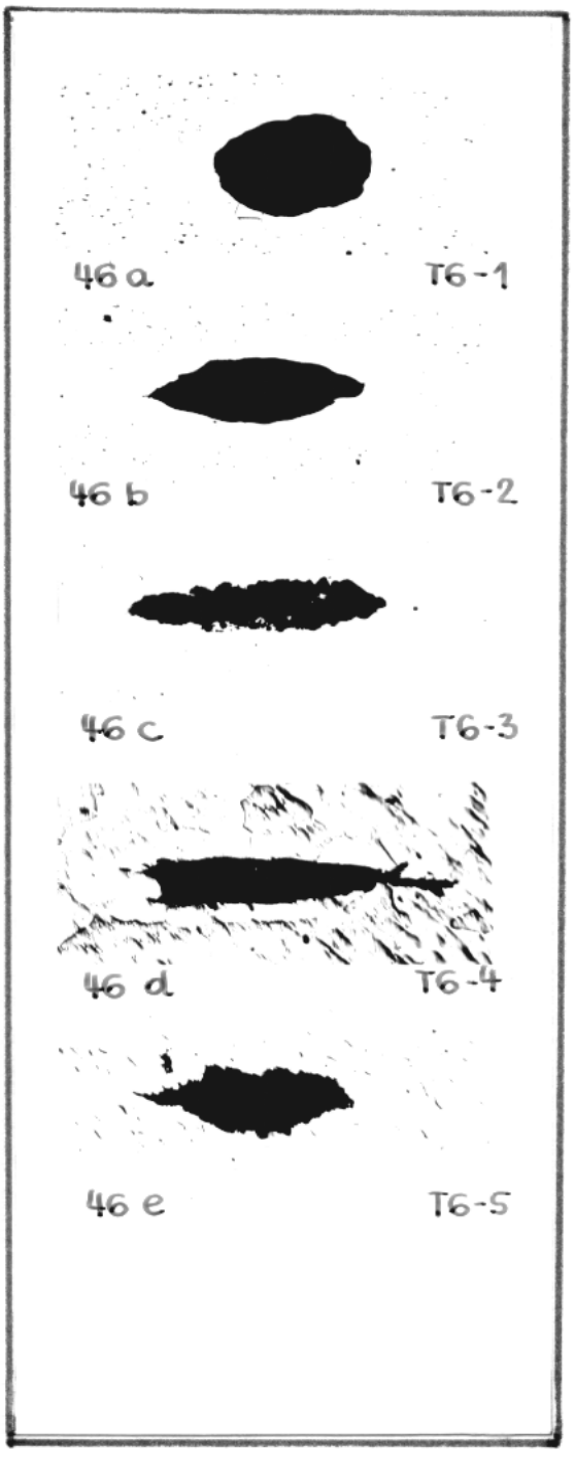


45 g ×500 c.p.

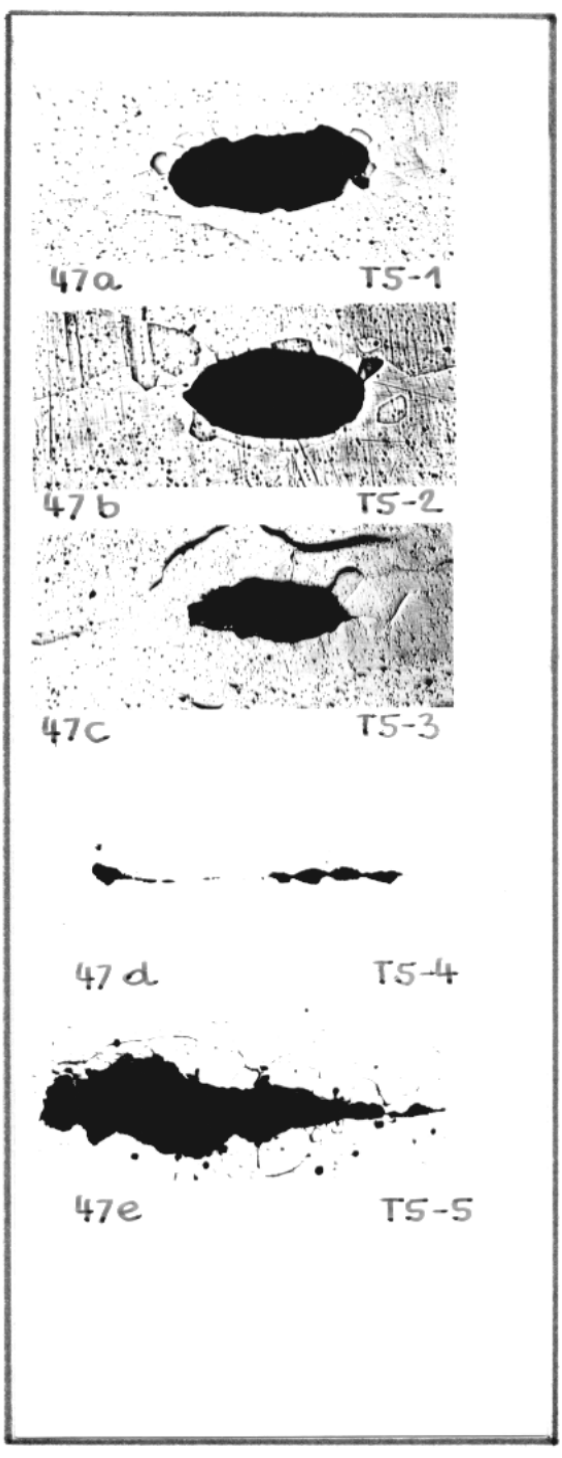


45 h ×500 c.p.

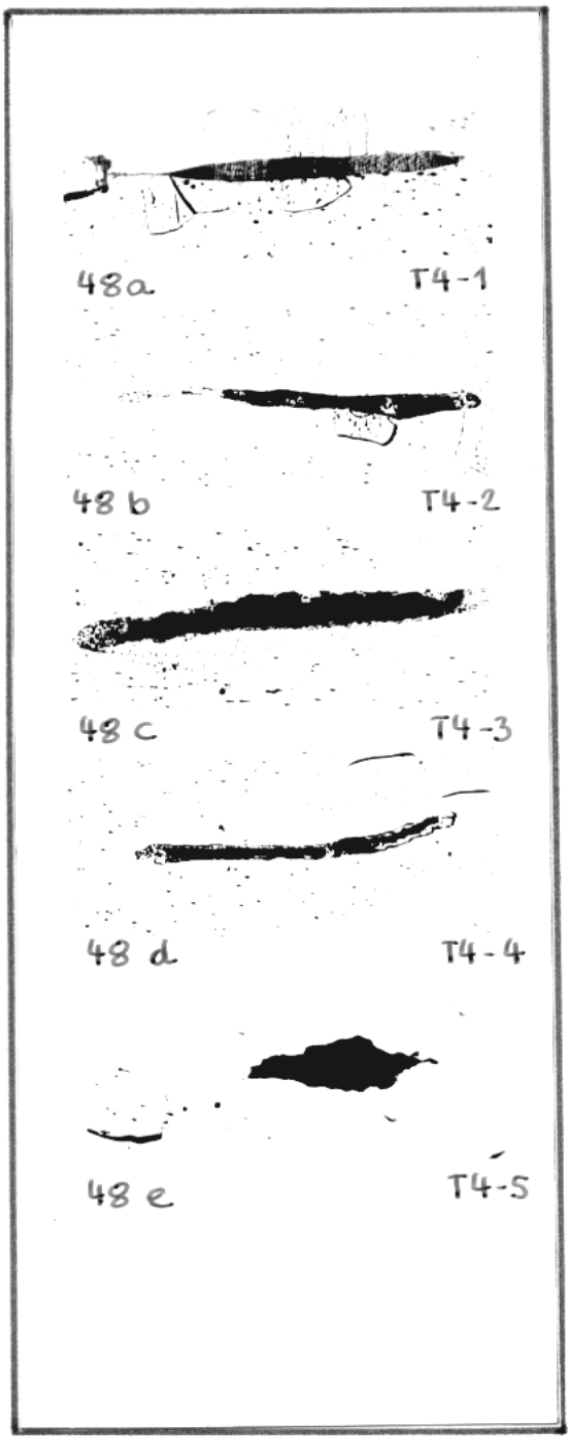
FOT. 46



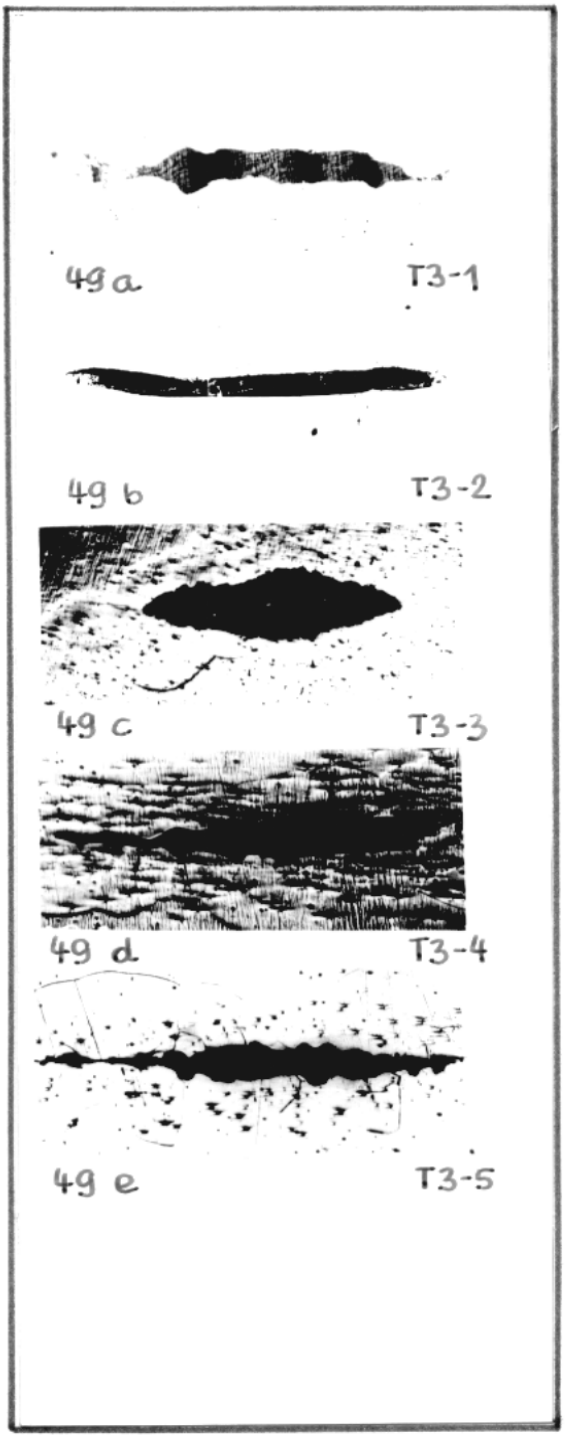
FOT. 47



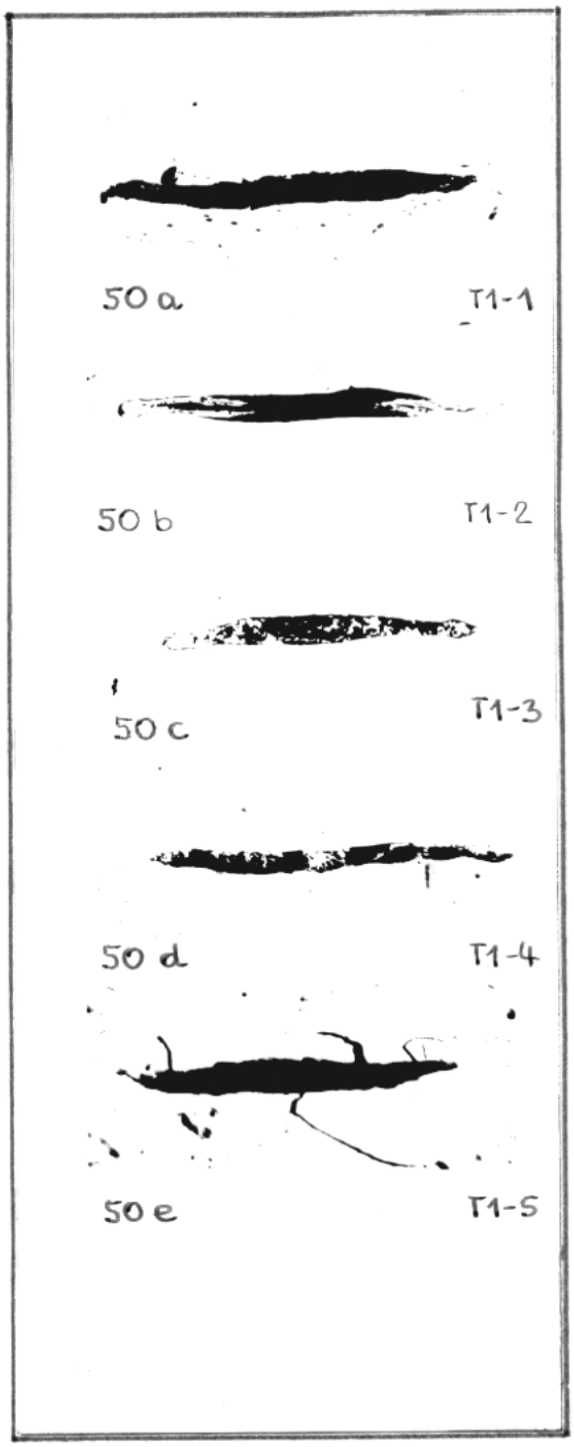
FOT. 48



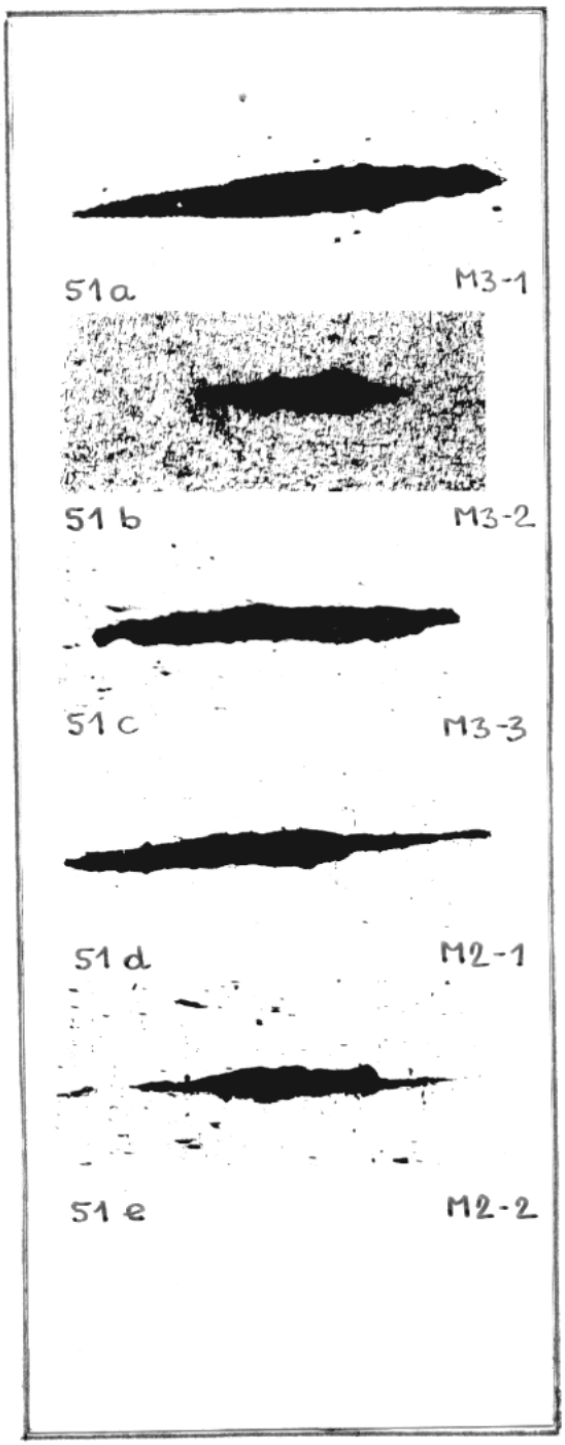
FOT. 49



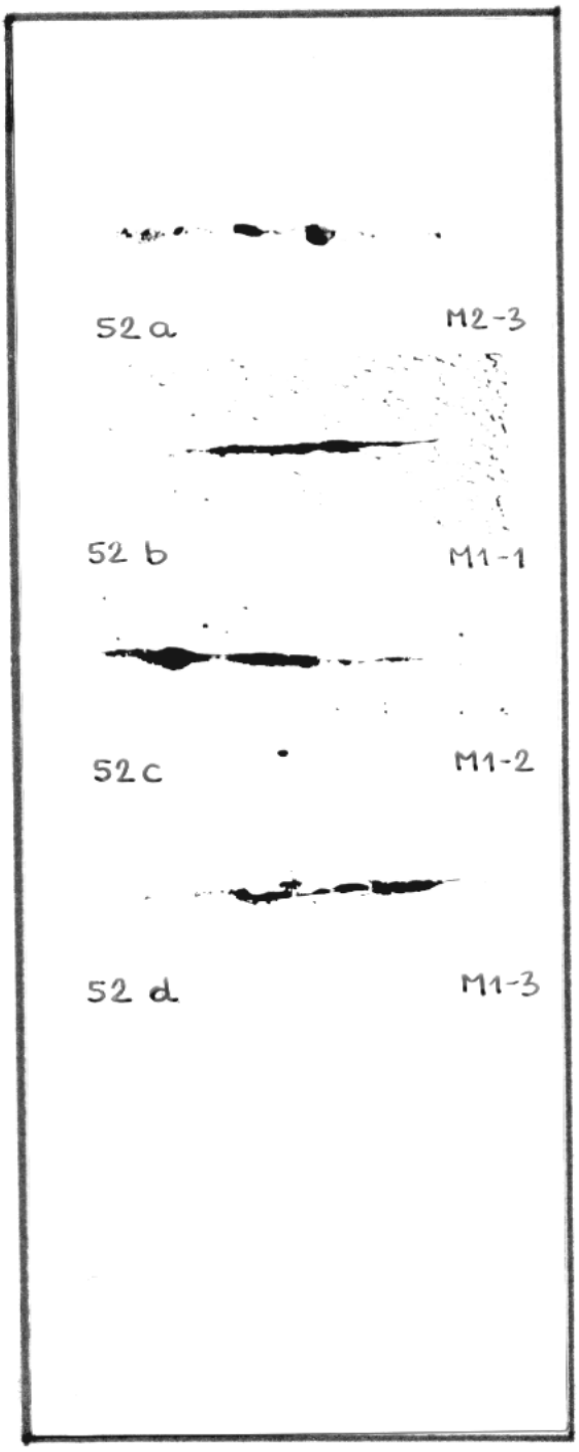
FOT. 50



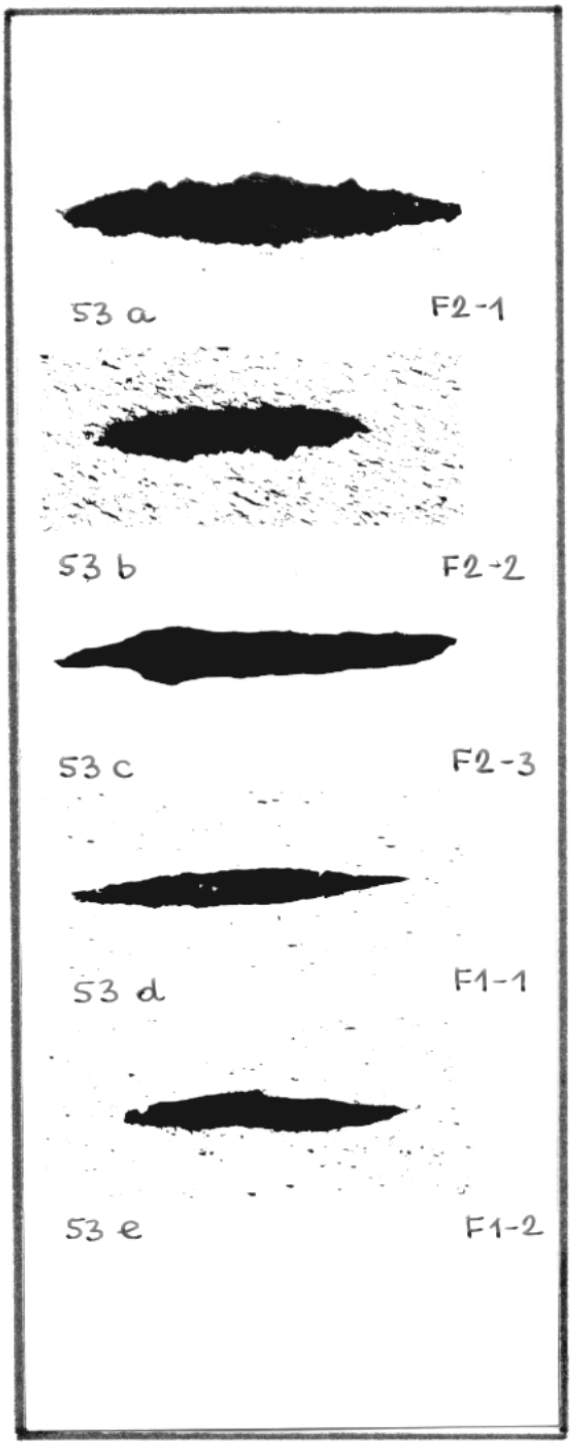
FOT. 51



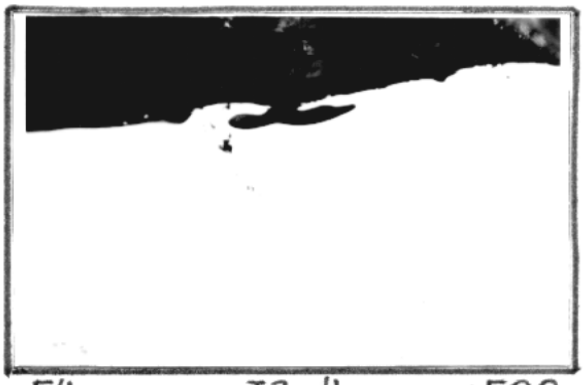
FOT. 52



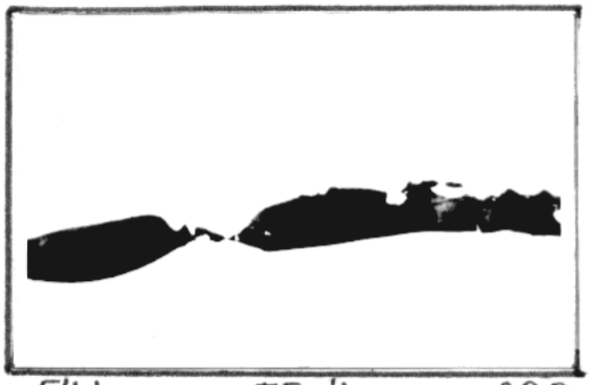
FOT. 53



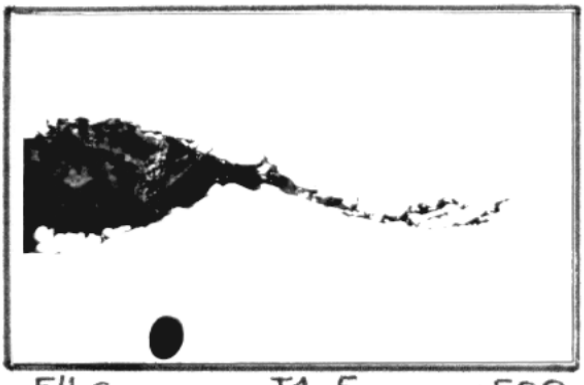
FOT. 54



54a T3-4 ×500



54b T5-4 ×200



54c T1-5 ×500

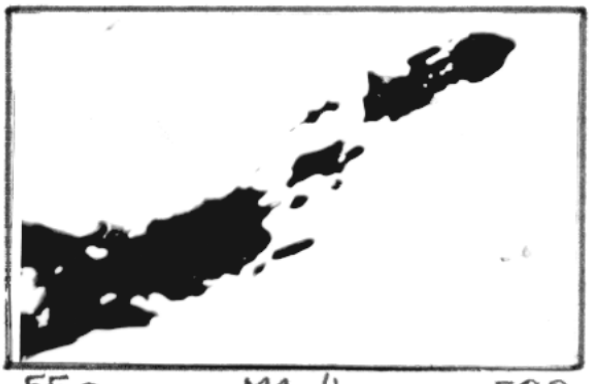
54d T4-5 ×500

54e T3-4 ×500

FOT. 55

55a M1-1 ×100

55b M1-2 ×500



55c M1-4 ×500

55d F1-1 ×200

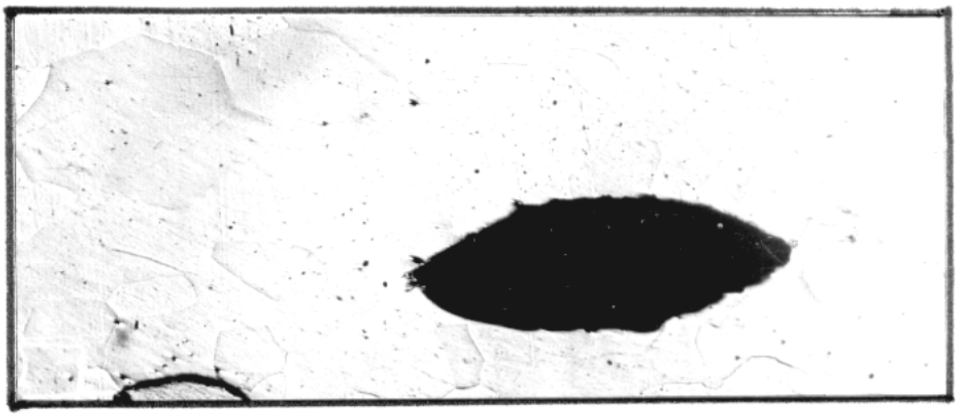
55e M1-1 ×500

FOT. 56

56 a

Δh = 2 mm

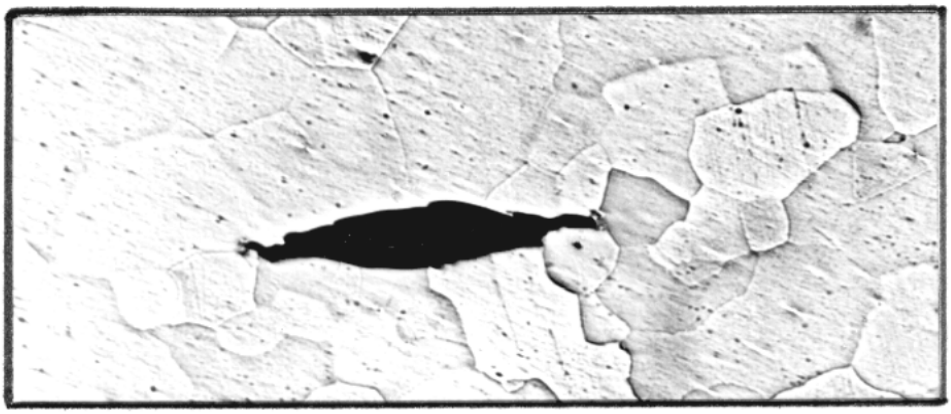
× 12,5



56 b

Δh = 3 mm

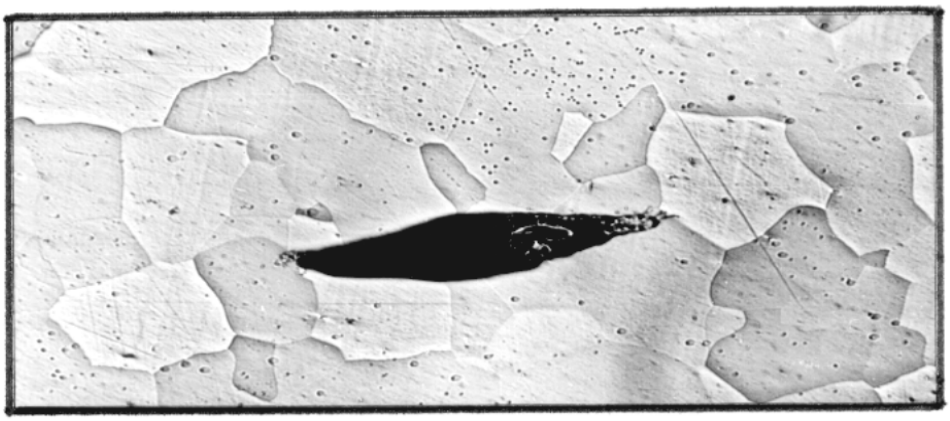
× 10



56 c

Δh = 4 mm

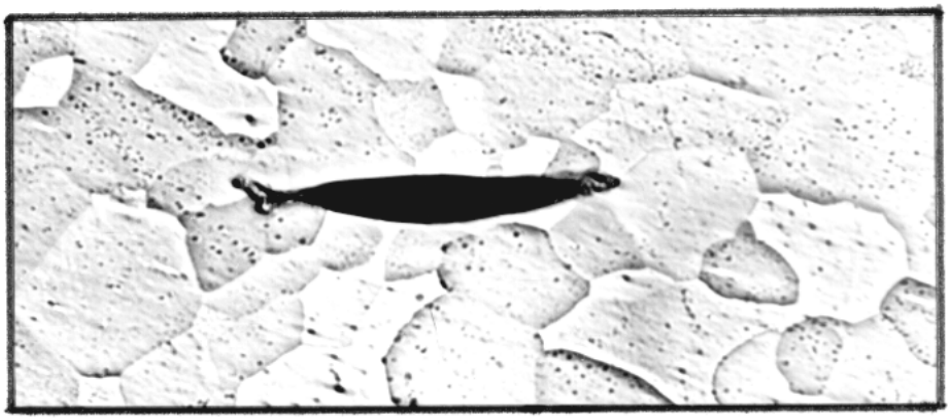
× 10



56 d

Δh = 5 mm

× 10

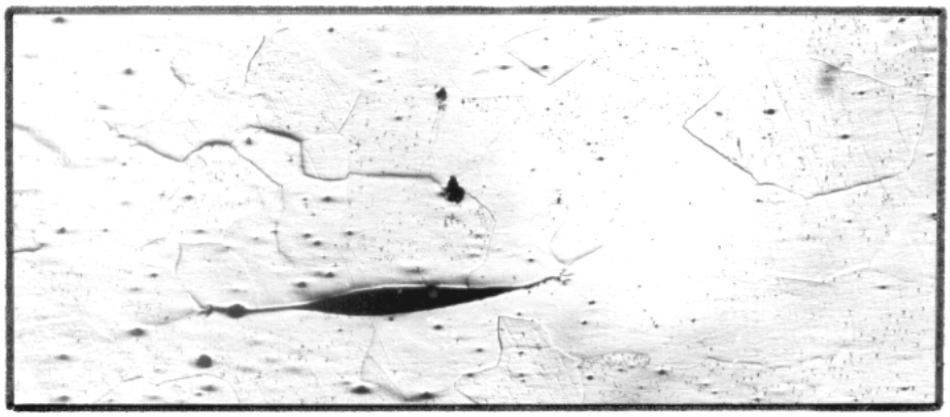


56 e

Δh = 6 mm

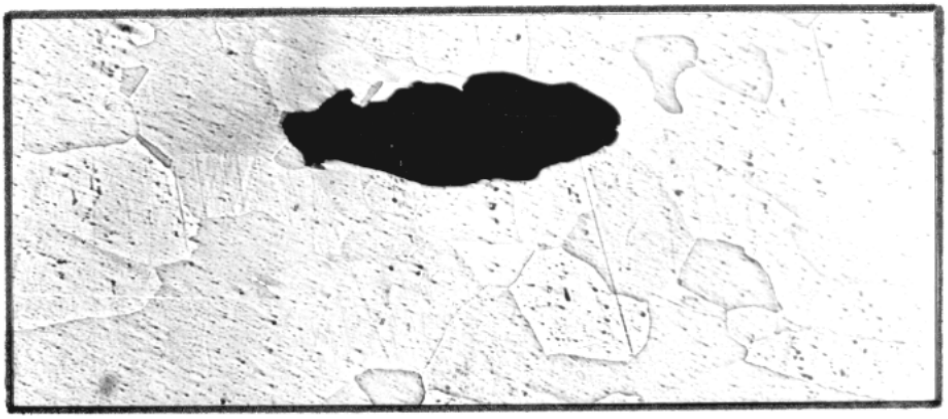
× 10

56f
x 10
Δh = 7mm



FOT. 57

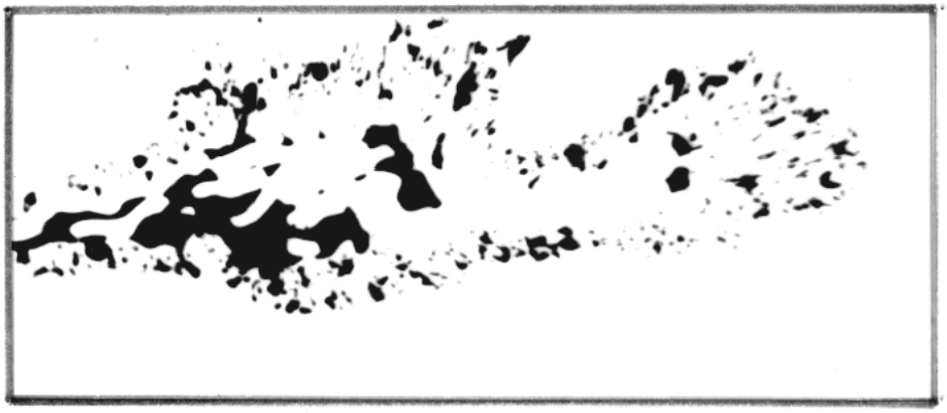
57a
x 12,5
Δh = 2mm



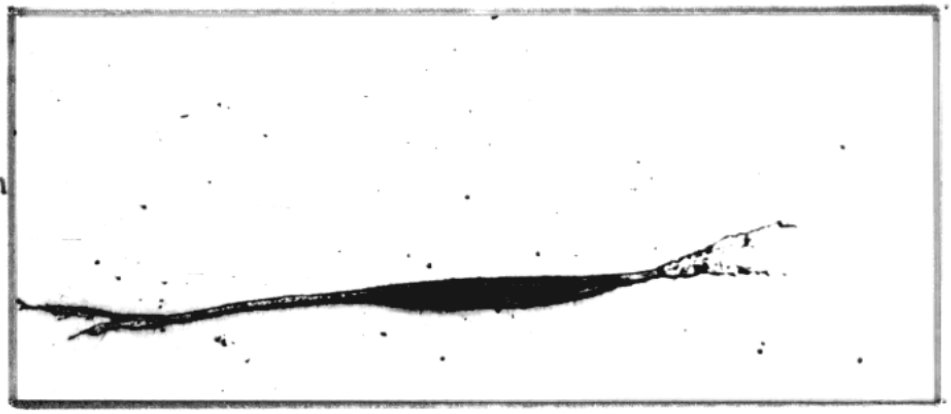
57b
x 12,5
Δh = 3mm

57c
× 25
Δh = 6mm

57d
× 200
Δh = 6mm



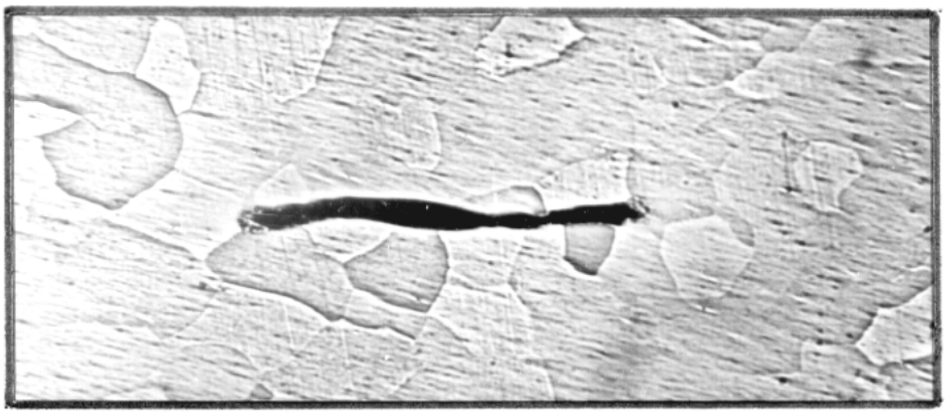
57e
× 25
Δh = 7mm



FOT. 58

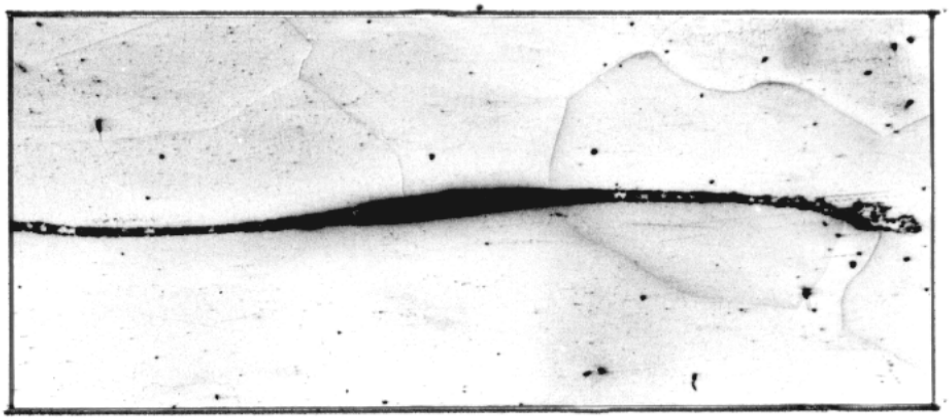
58a
× 12,5
Δh = 2mm

58b
×12,5
Δh=3mm



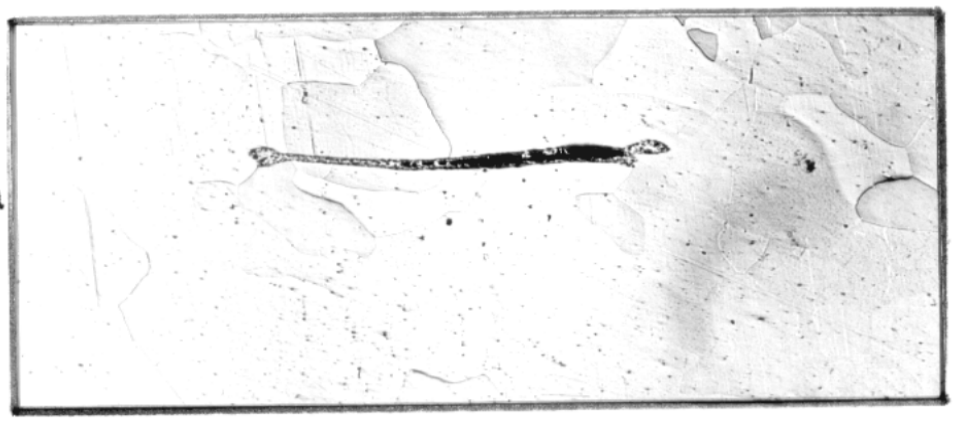
58c
×12,5
Δh=5mm

58d
×25
Δh=5mm

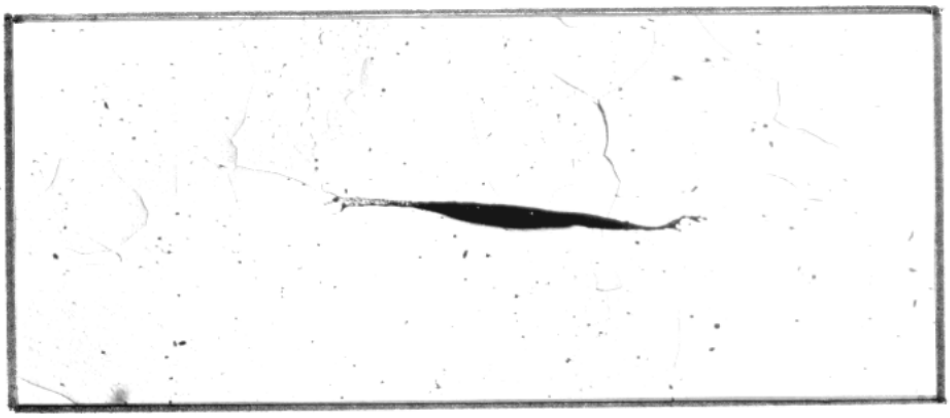


58e
×200
Δh=5mm

58f
×10
Δh=6mm

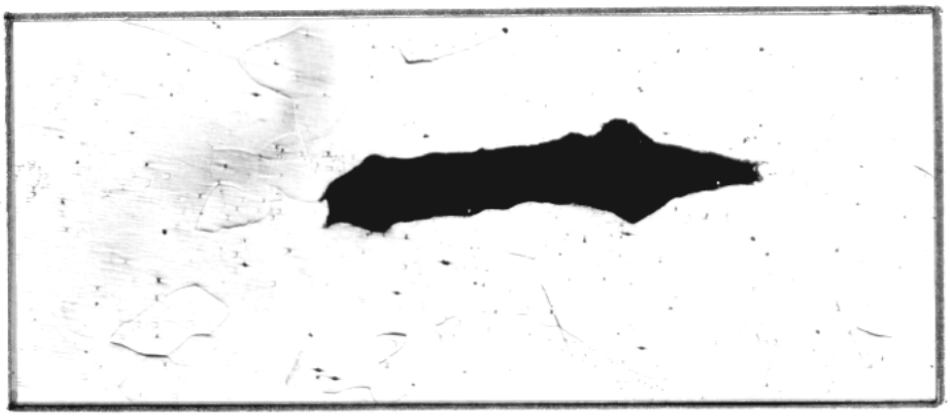


58g
×10
Δh=7mm

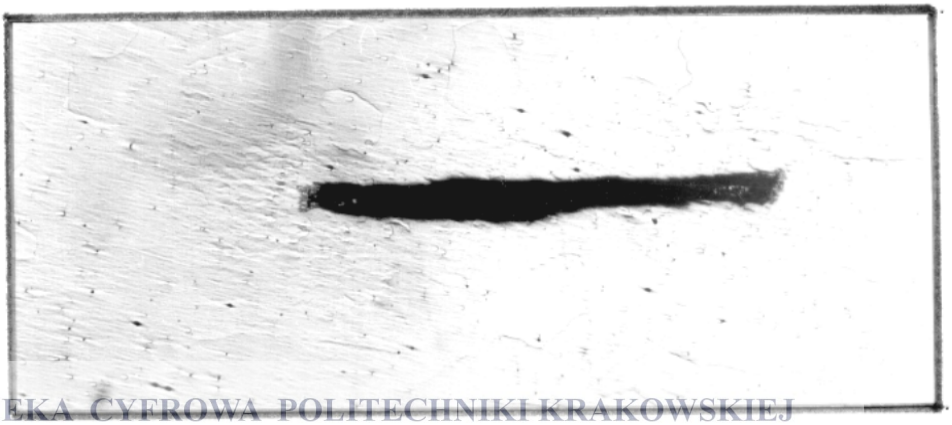


FOT. 59

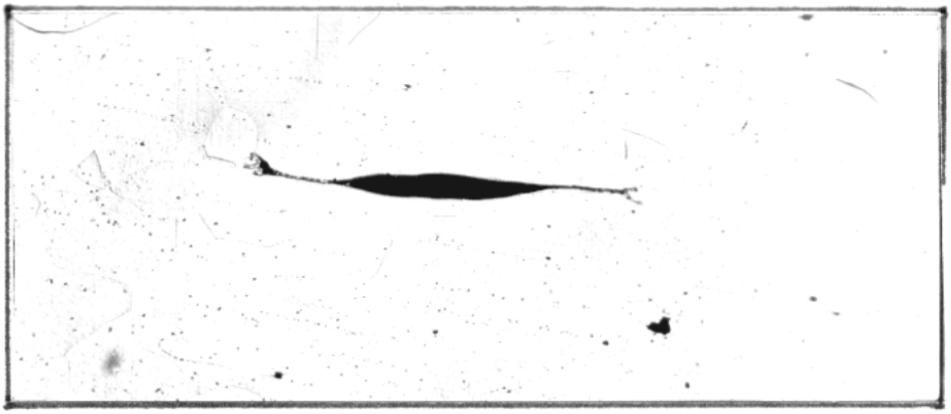
59a
×12.5
Δh=2mm



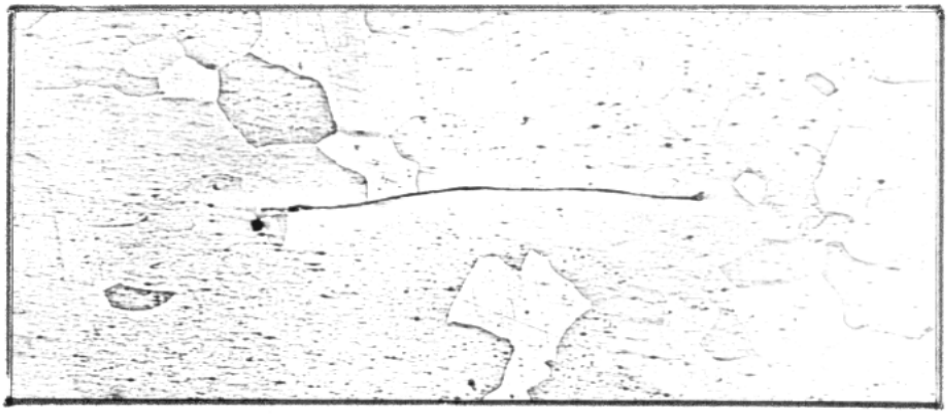
59b
×12.5
Δh=3mm



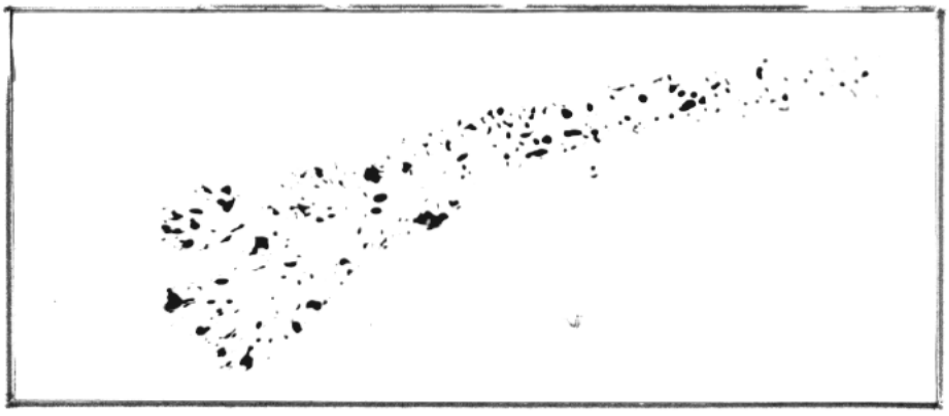
59c
x 10
Δh = 6 mm



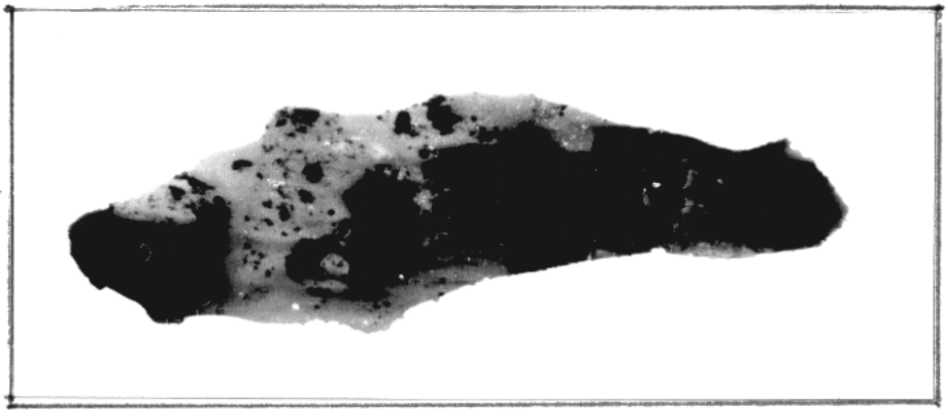
59d
x 12,5
Δh = 7 mm



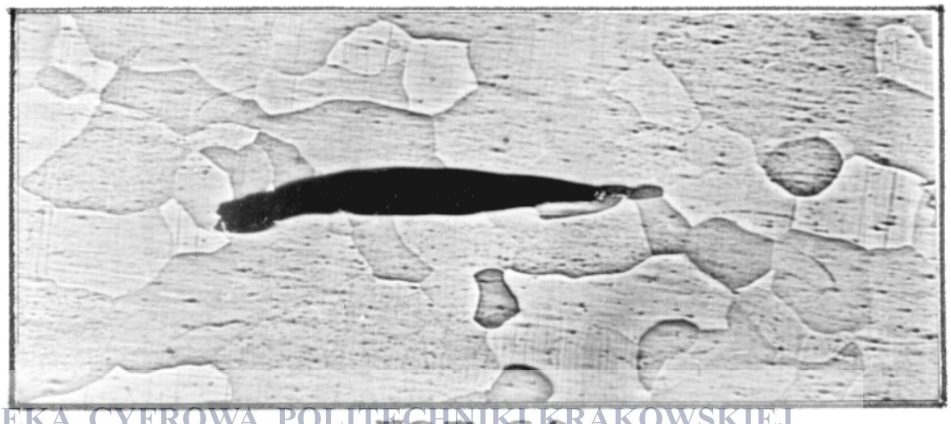
59e
x 200
Δh = 7 mm



60a
x 25
Δh = 2 mm



60b
x 12,5
Δh = 7 mm

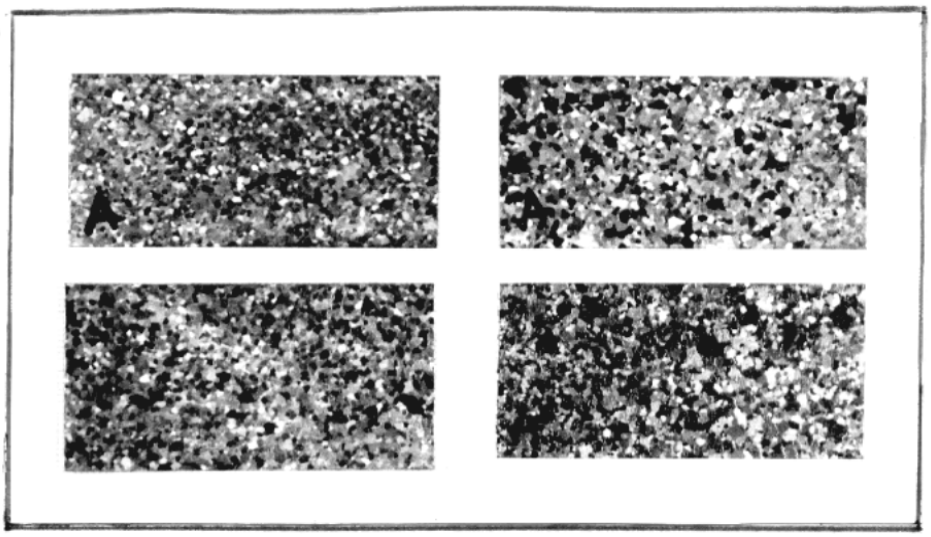


FOT. 60

FOT. 61

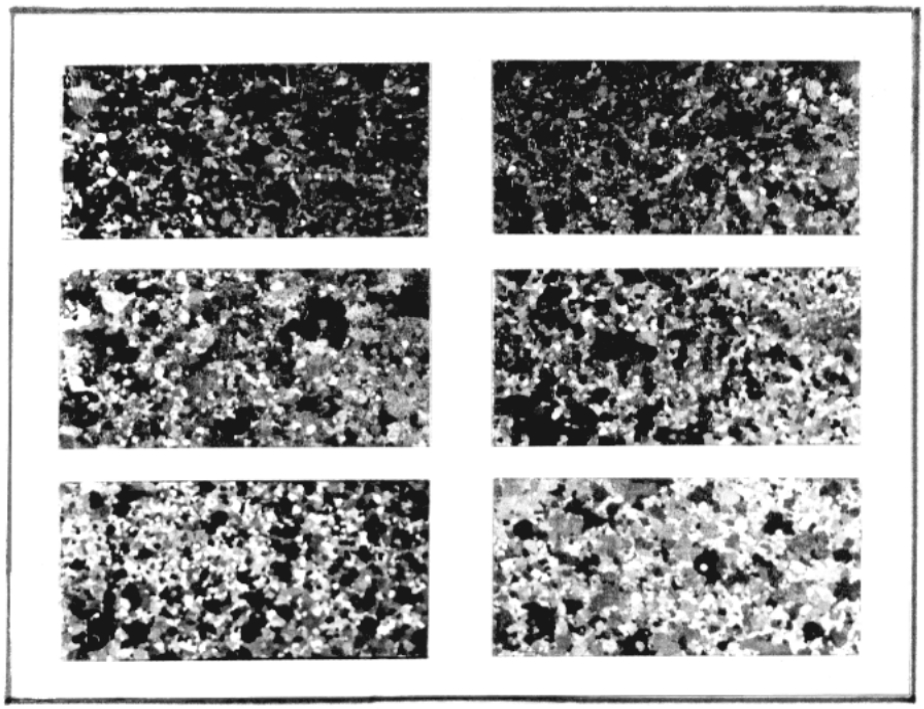
61a

PRÓBY A



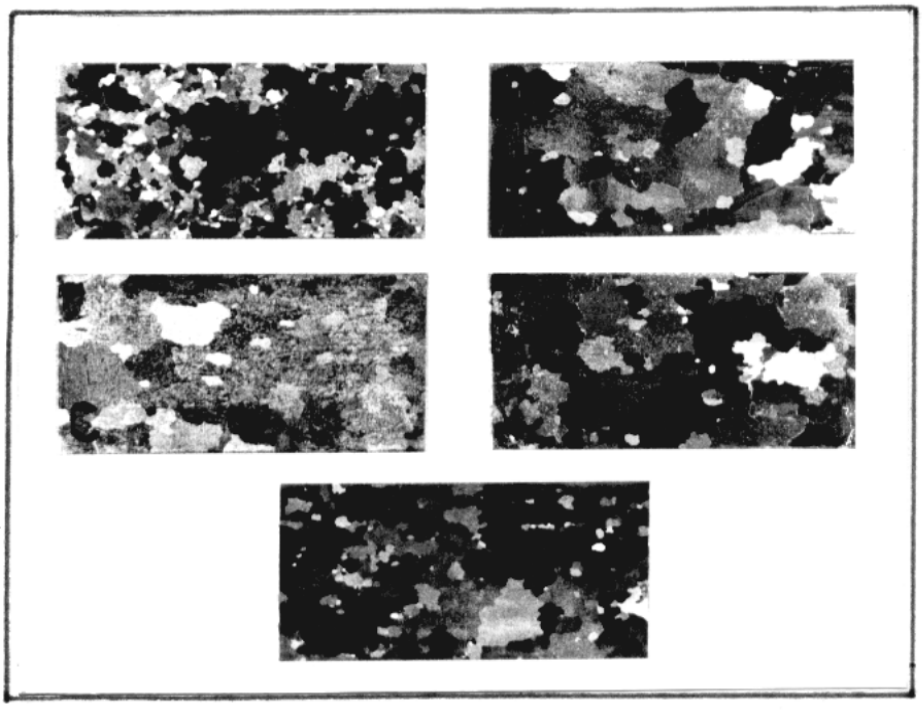
61b

PRÓBY B

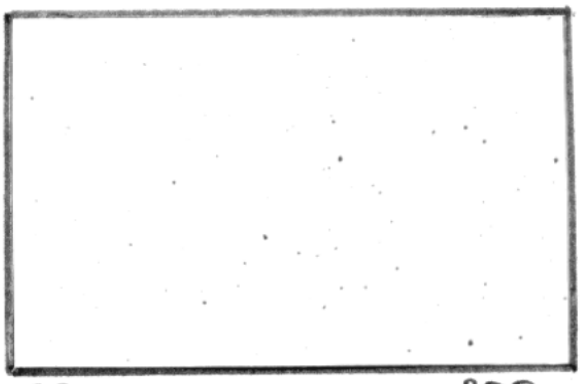


61c

PRÓBY C

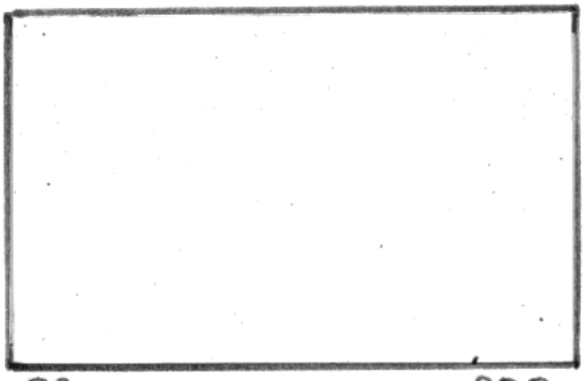


FOT. 62



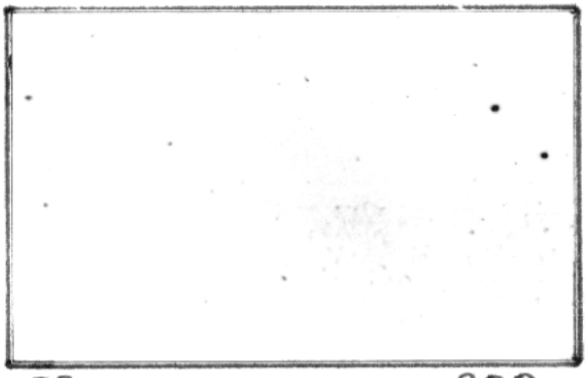
62a ×200

62b ×200 c.p.



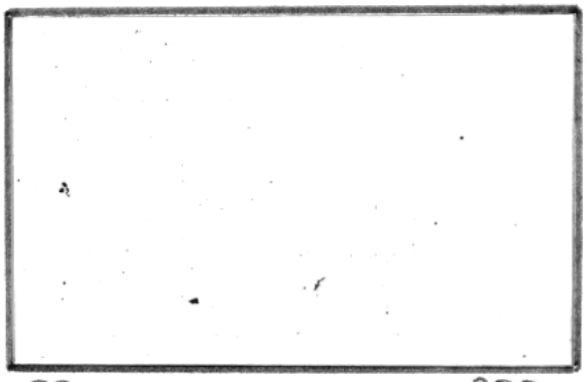
62c ×200

62d ×200 c.p.



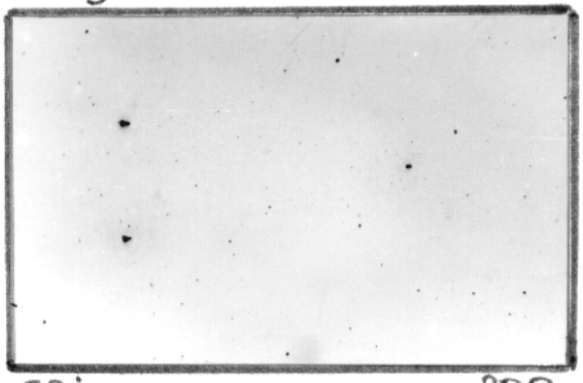
62e ×200

62f ×200 c.p.

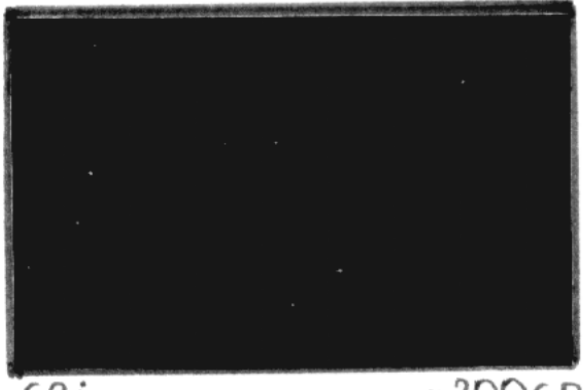


62g ×200

62h ×200 c.p.

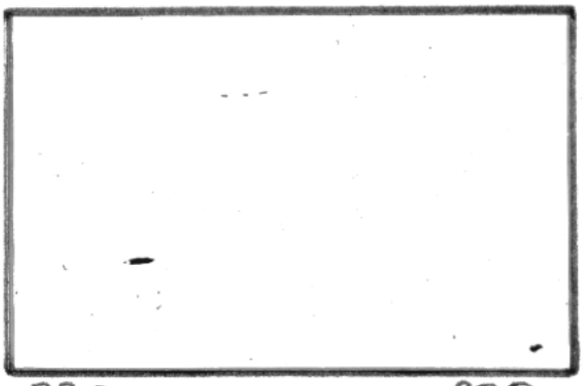


62i ×200

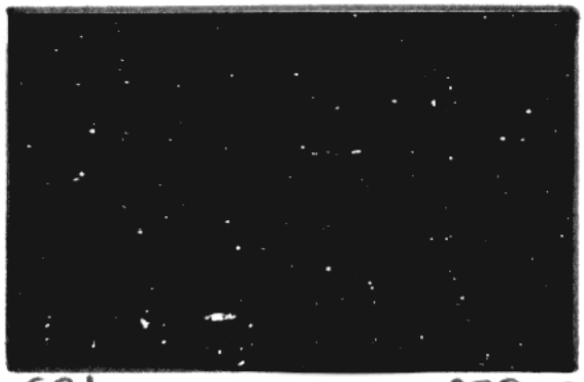


62j ×200 c.p.

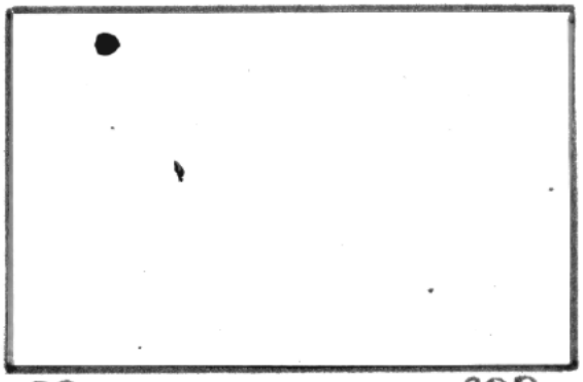
FOT. 63



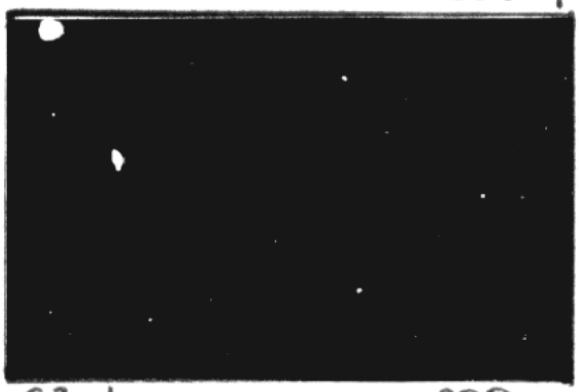
63a ×200



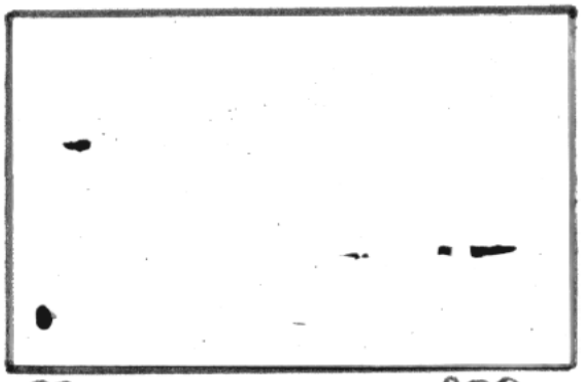
63b ×200 c.p.



63c ×200

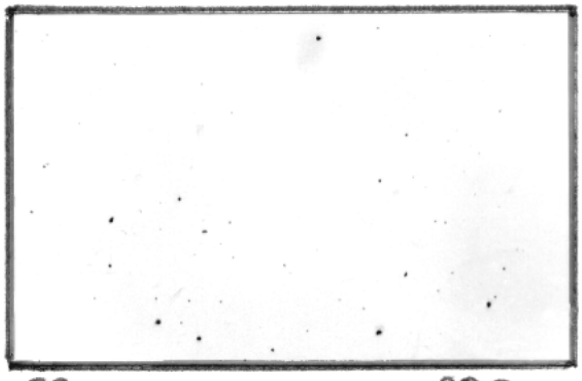


63d ×200 c.p.



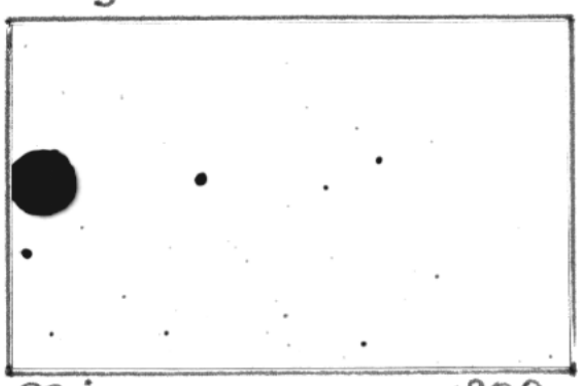
63e ×200

63f ×200 c.p.

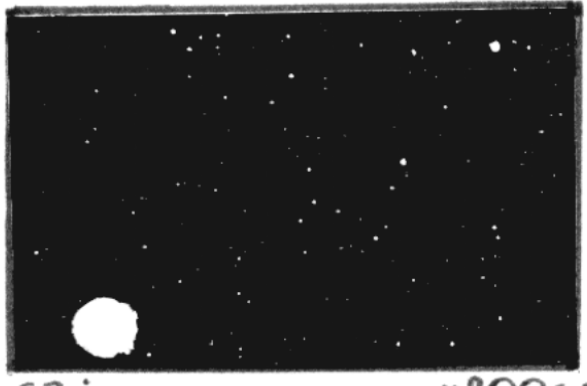


63g ×200

63h ×200 c.p.

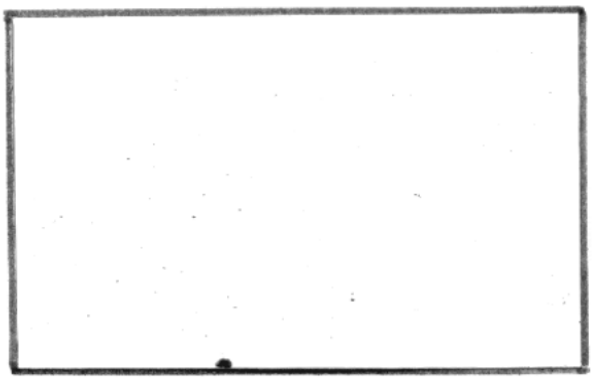


63i ×200



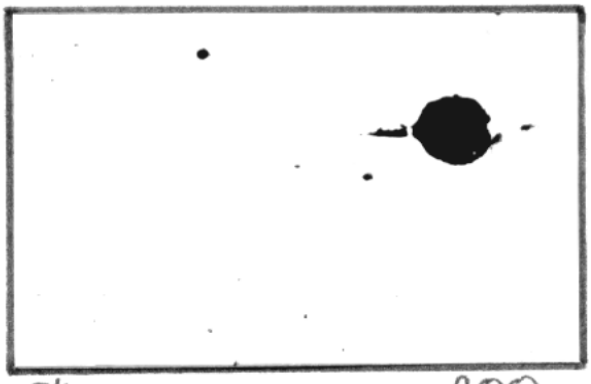
63j ×200 c.p.

FOT. 64

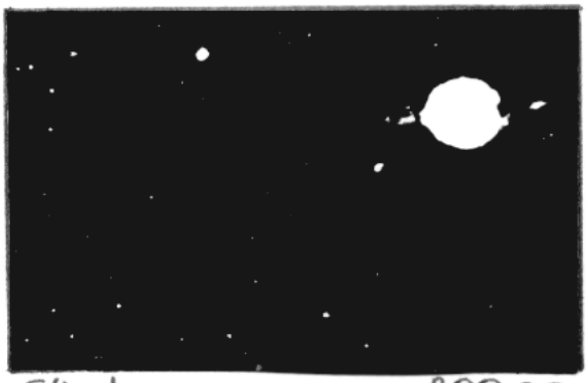


64a ×200

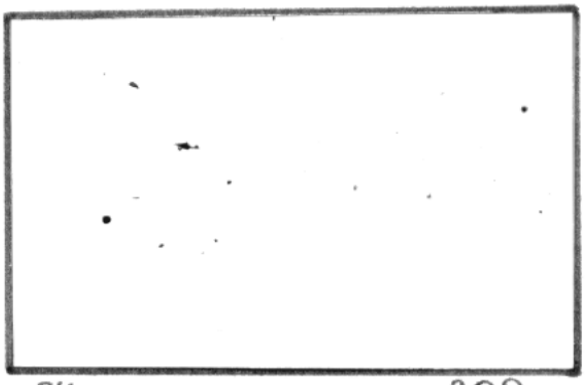
64b ×200 c.p.



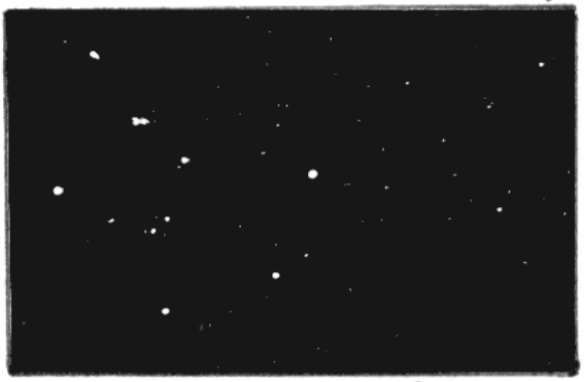
64c ×200



64d ×200 c.p.



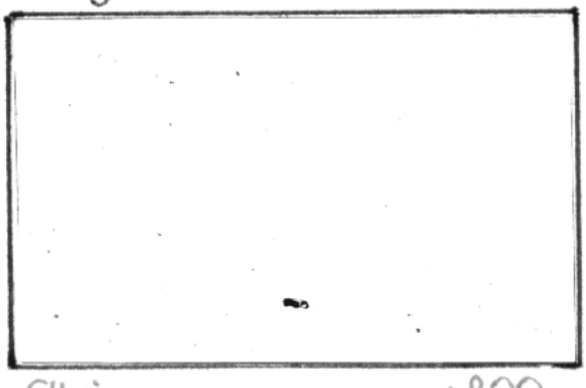
64e ×200



64f ×200 c.p.

64g ×200

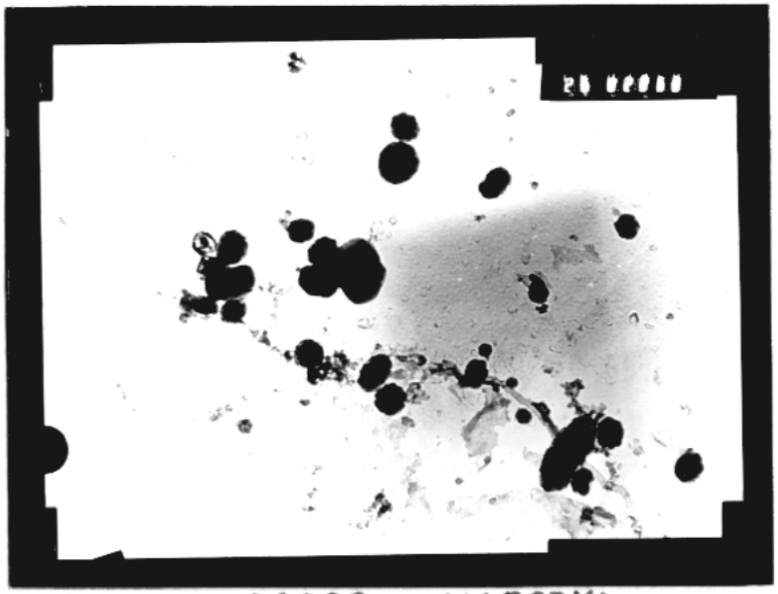
64h ×200 c.p.



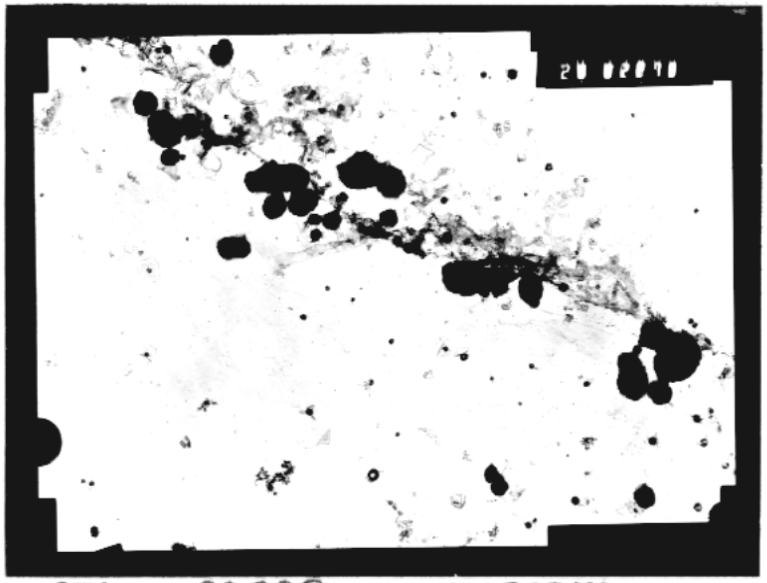
64i ×200

64j ×200 c.p.

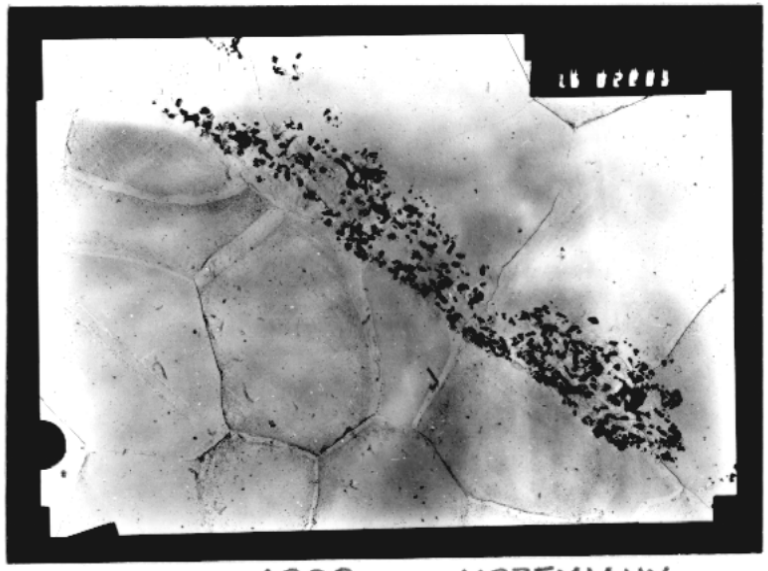
FOT. 65



65a x 26000 SIARCZKI

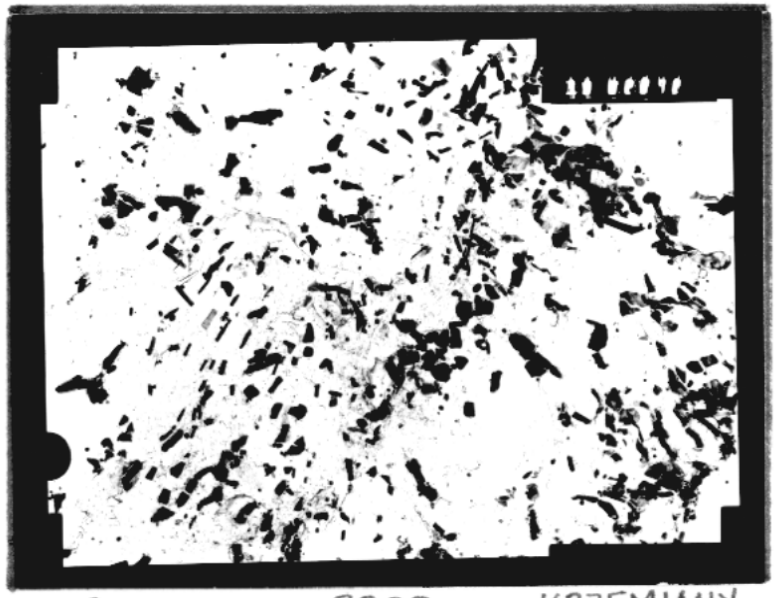


65b x 26000 SIARCZKI

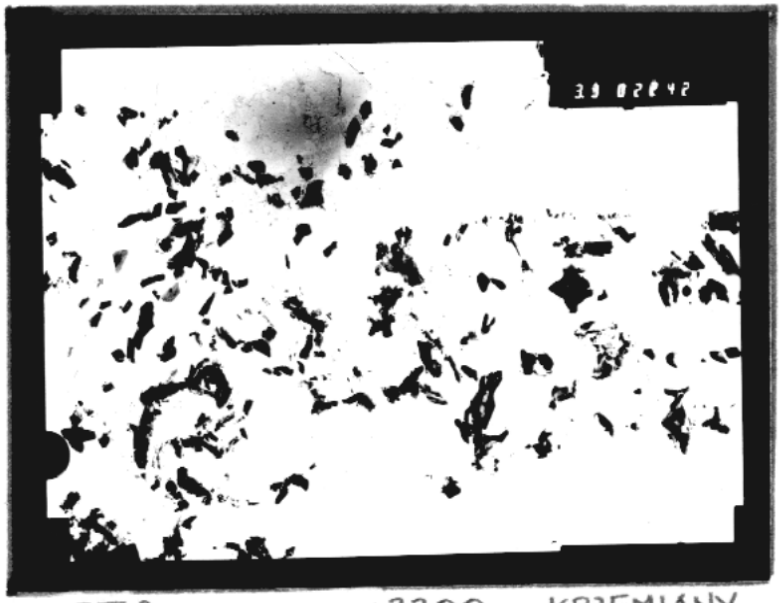


65c x 1600 KRZEMIANY

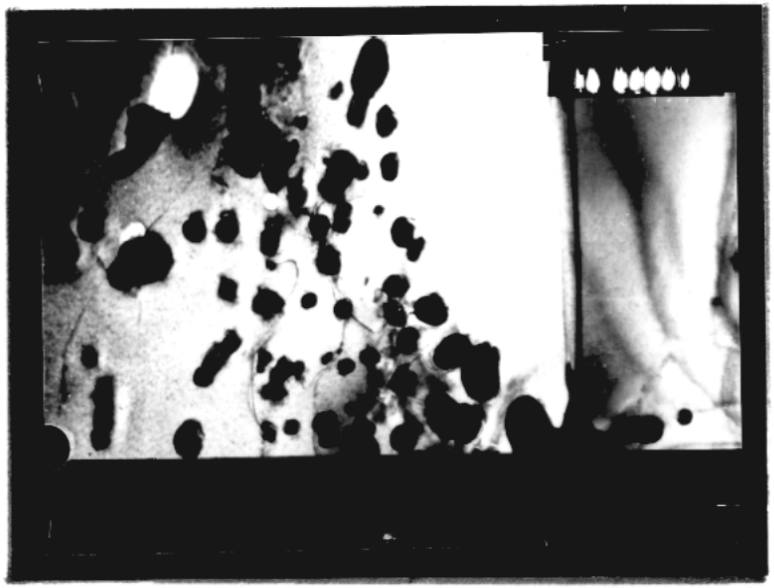
65d x 3300 KRZEMIANY



65e × 3300 KRZEMIANY



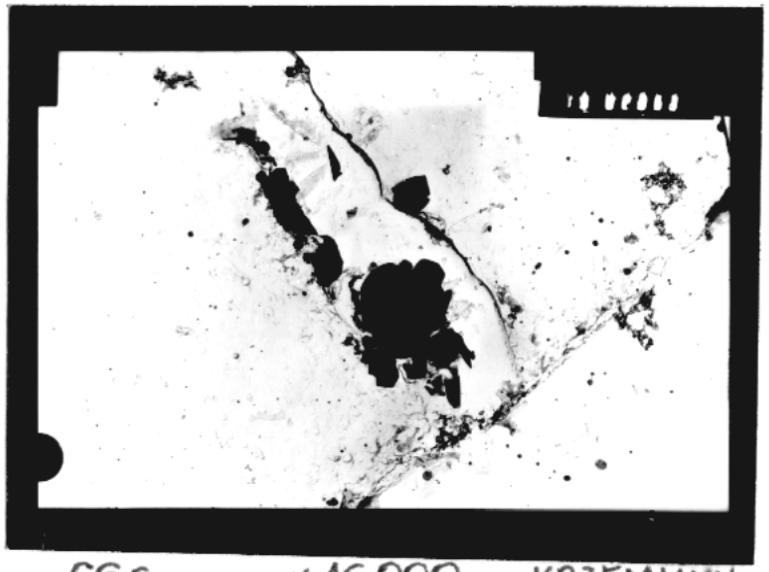
65f × 3300 KRZEMIANY



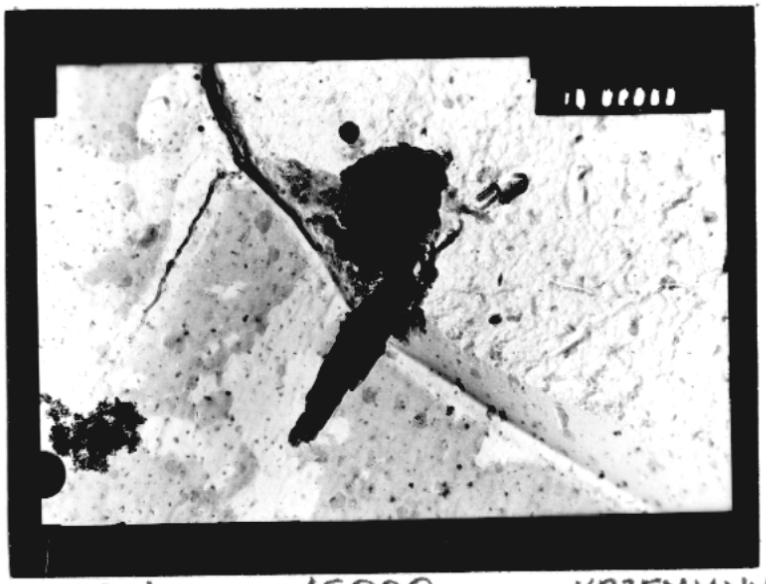
66a × 16 000 SIARCZKI

FOT. 66

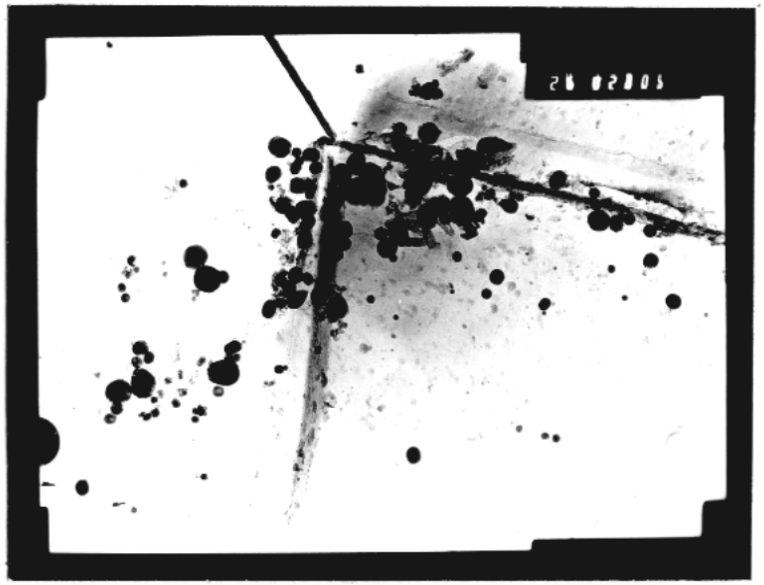
66b × 16000 SIARCZKI



66c × 16000 KRZEMIANY

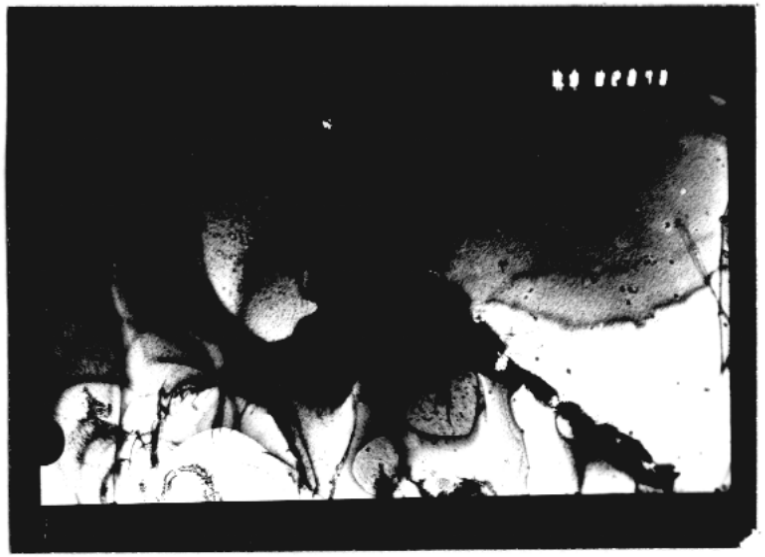


66d × 16000 KRZEMIANY

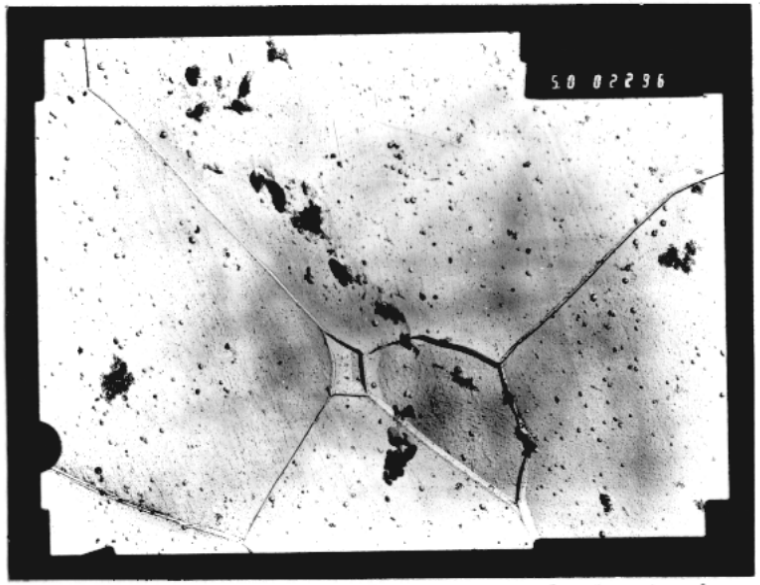


67a × 26000 SIARCZKI

FOT. 67

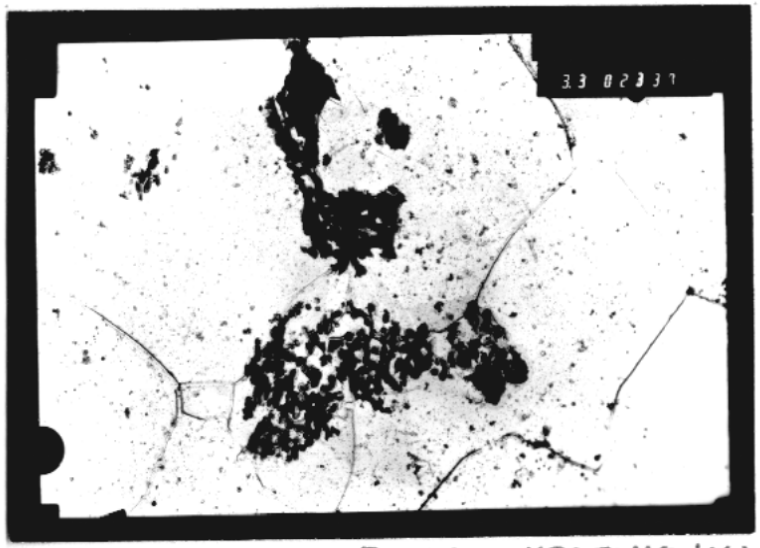


67b × 8900 SIARCZKI

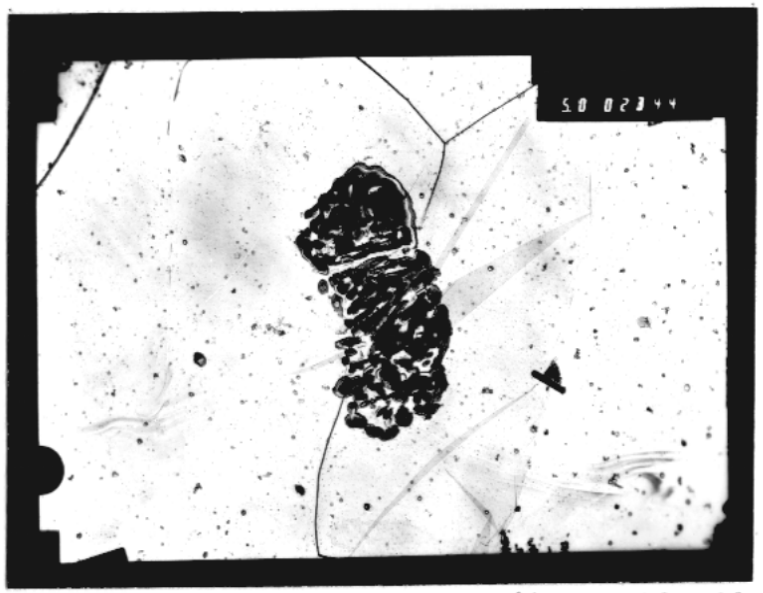


67c ×5000 KRZEMIANY

67d ×13000 KRZEMIANY



67e ×3300 KRZEMIONKA



67f ×5000 KRZEMIONKA