IMAGE ANALYSIS & QUANTITATIVE METALLOGRAPHY

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INTRODUCTION

The metallographic examination constitutes simply a planar section view of a three dimensional structure. It is not enough to recognize this fact; one must also understand how shape in a three dimensional construction can degenerate into traces in random planar section. In fact, one must be able by mental visual skill to recreate from slices of hard boiled egg, the oblate ellipsoid when they came. For example, an inclusion, or porosity can appear to be different when observed in different planer section and the assessment of volume will be qualitative and only quantitative to the extent of visual judgement. Actual quantitative evaluation of inclusion and porosity, their shape and size distribution are very important for predicting the mechanical properties of the metals and alloys. Similarly, the grain size is another important factor in the hardenability of steels, ductility of brass and in the ductile-brittle transition of alloys. The amount of ferrite in stainless steels is a factor in their foregeability. The average flake size of graphite is a control parameter in the strength of gray cast iron. These are only a few instances where numerical limits to metallographic parameters are practical factors in quality or production control. Since we can not obtain large number of specimens to get correct three dimensional picture, quantitative analysis is an appropriate alternative. Two factors must be assumed in all such quantitative studies. The planar section or sections be representative of the whole. In the matter of arriving at average values for dimensions of distributed particles one must have a knowledge of the actual or approximate shape of the particles. Few particles are actually perfectly spherical, but this is a mathematical convenience.

Kinds of Measurement

The quantities one may wish to determine can be derived from one or more of several kinds of measurements based upon real analysis, point counting, and lineal analysis.

Areal analysis involves the measurement with a planimeter (or by other means) of the area of a microconstituent intercepted by a planar cross section. Point counting involves the superposition of an appropriate line grid such as transparent graph paper into a microstructural feature, counting the number per unit area of grid intersections which fall on that type of feature. Lineal analysis involves the estimate of the proportion per unit length of a random line superimposed on a micrograph occupied by the specific type of microstructural feature. Lineal analysis involves the estimate of the proportion per unit length of a random line superimposed on a micrograph occupied by the specific type of microstructural feature. In another version of this, a count is made of the number of intersections per unit length which a random line makes with a specific type of distributed particle.

A basic rule in quantitative observations made on planar section is that all three ratios are equal and that in turn they are equal to the volume fraction.

$$\frac{V\alpha}{V} = \frac{A\alpha}{A} = \frac{N\alpha}{N} = \frac{L\alpha}{L}$$

Earlier it used to be made manually and quantitative measurements were very time consuming and difficult. Thanks to computer technology, a large variety of Automatic Image Analysers are available and now we can measure grain size, particle size, distribution, aspect ration of odd shaped flakes of cast iron, retained austenite in ferrite, and ferrite in stainless steel with ease. However, the basic principle remains the same.

Measurement of Grain size

Most of the basic difficulties in quantitative metallography are contained in the problem of assignment of numerical magnitudes to the grains of a polycrystalline aggregate. All the grains may not be of same size and so on. Therefore, an average statistical concept is taken into consideration assuming all grains to be spherical.

One of the basic measurements in grain size determination is the number of grains counted per unit area of planar field of observation. From analysis of the distributions of sections which will be encountered in space occupied by truncated octahedra, the ASTM system gives the following relationship :

$$n = 2^{N-1}$$

where n = number of grains per square inch. at 100 x magnification

& N = ASTM grain size number

Standard charts are available and by comparing the microstructures at 100 x magnification one can determine the ASTM grain size of the microstructures. Image Analysers are now available for this with suitable programming.

Measurement of Particle Sizes

The volume fraction of a dispersed phase can be determined by simple lineal, areal, or point count analysis and this determination is independent of the shape, ideal or otherwise, which the particles posses. This is not true, however, for the problem of estimating the number of particles per unit volume and the dimensions of particles. In both the cases, the shape of the particle must be known. In practice one must be able to decide whether the distributed phase approximates a sphere, a disc, a rod, an ellipsoid, or some such ideal geometric shape. Relationships have been derived for particle density and dimensions using parameters measurable on a polished section. Each relationship pertains to a specific geometric shape and assumes a uniform size distribution. The problem of nonuniform size distribution must be considered separately. However, all these rigorous mathematical derivations are beyond the scope of present course. Quantitative metallography equipments can do these without any human factor, except to use them with skill. A histogram of particle size and volume can obtained easily which gives the idea of distribution. Normally inclusions are determined by this method. However, for day to day work, ASTM charts are available which are designated A, B, C & D for Sulphides, Alumina, Silicates and Oxides types of inclusions. They are thick and thin. All these charts are at 100 x magnifications. By comparison with these charts, inclusions of the microstructures can be identified and quantified. The volume % of these inclusions can be measured with the help of Image Analyser.

Automatic Image Analyser

Now-a-days a large number of versatile programmed Automatic Image Analysers are available for quantitative metallography. These can be operated manually also. The image analyser is interfaced with an optical microscope which produces microstructures and is transmitted to TV screen with the help of TV camera. It works on the basic principle of differentiating between the greyness of phases or particles, which can be initiated electronically as per choice. Once initiated, these phases or particles can be measured both manually as well as by automatic computer programming. The image analysers have got three options, namely area, count and intercept functions. Sometimes we may like to edit the picture on TV screen. Therefore, image editors are also available with image analyser. Besides optical microscope, the TV camera can be shifted for analysing the photographs also. No metallography laboratory can be complete without image analyser.

However, for routine type of industrial work ASTM charts for ASTM grain size, inclusions charts for Alumina, Sulphides, Silicates and Oxides are sufficient, as the image analysers are very costly and are needed for advanced quantitative metallography only. Here, one thing must be mentioned that special etching is needed to produce different greyness to the required phases, without which image analyzer is useless. Probably, colour metallography laboratory is a must.

REFERENCES

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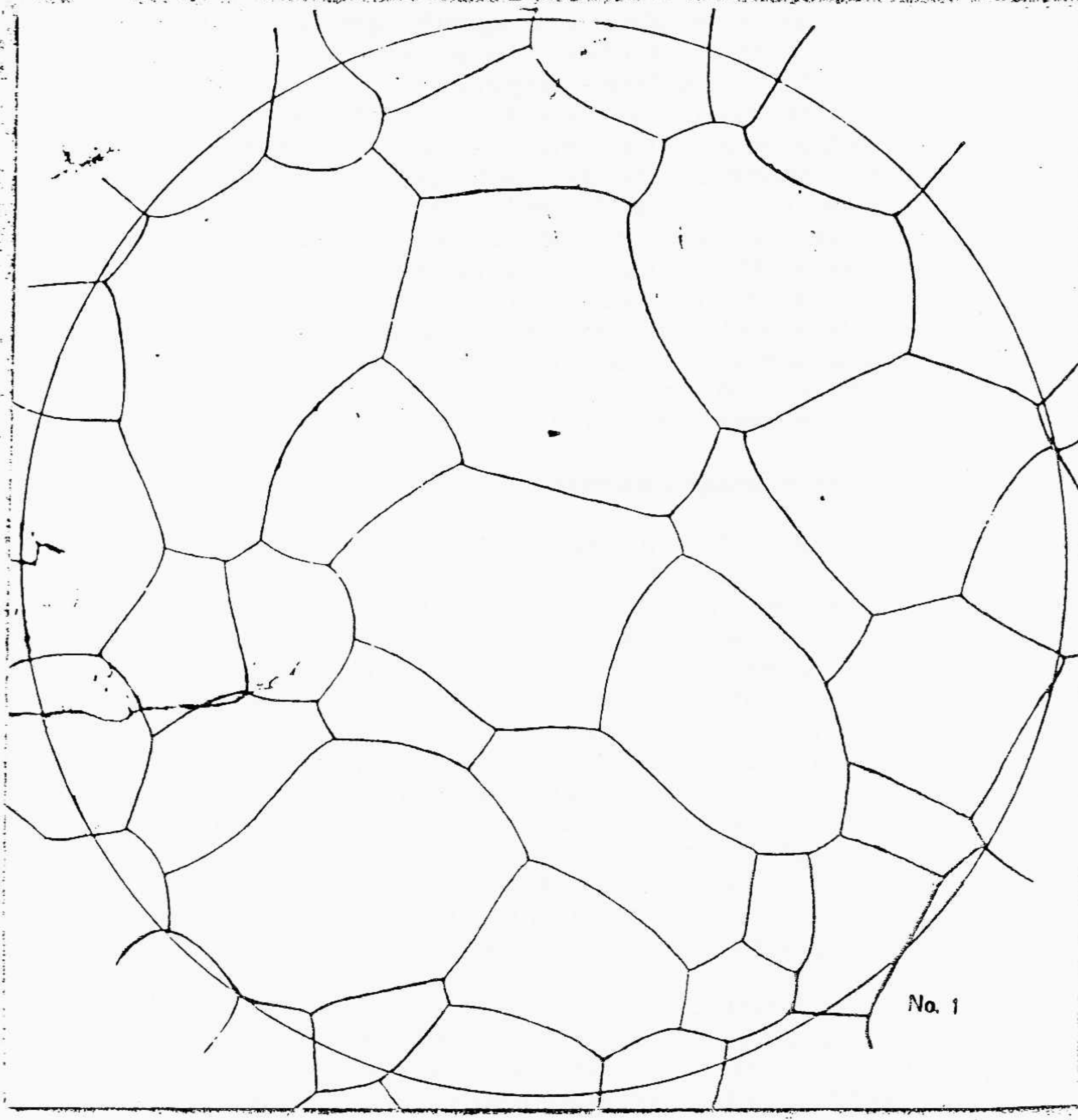

AMERICAN SOCIETY FOR TESTING MATERIALS
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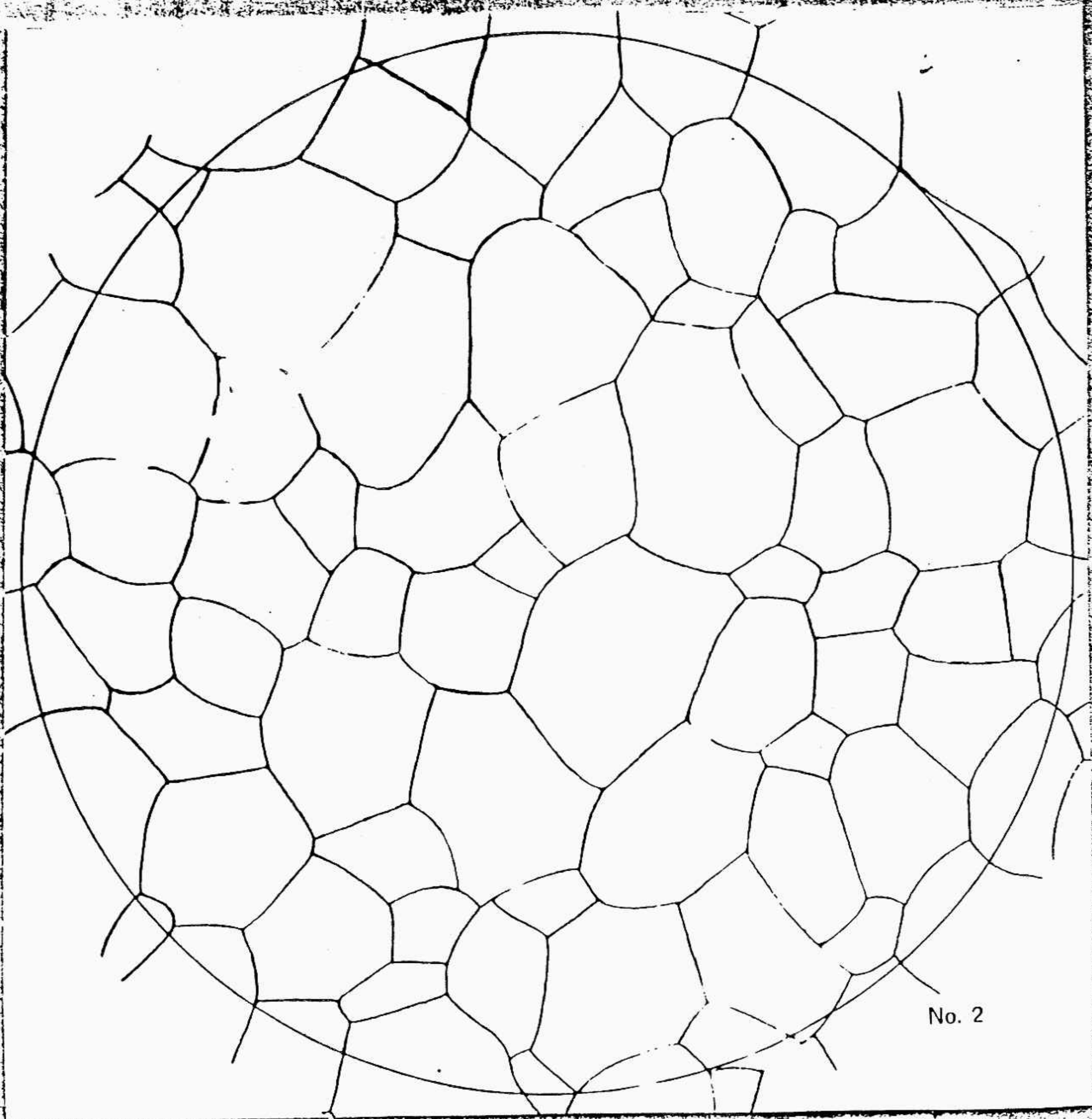
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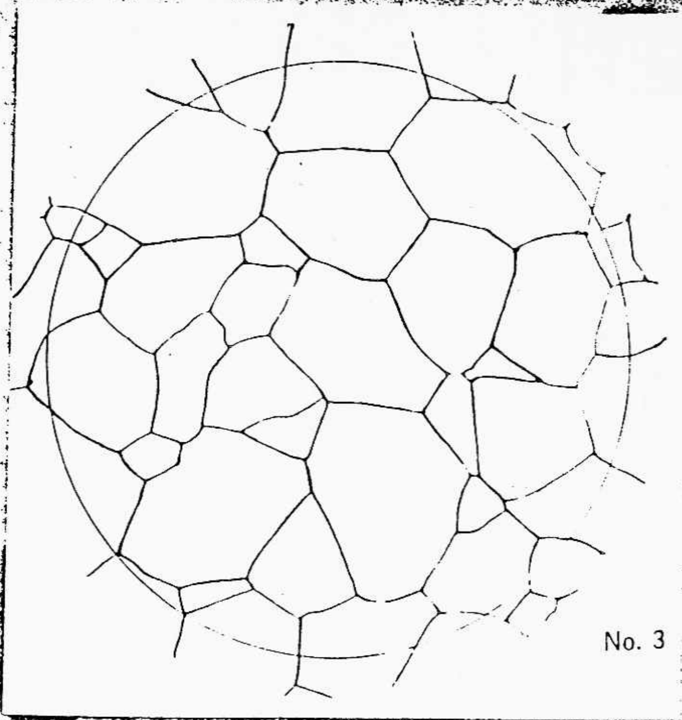

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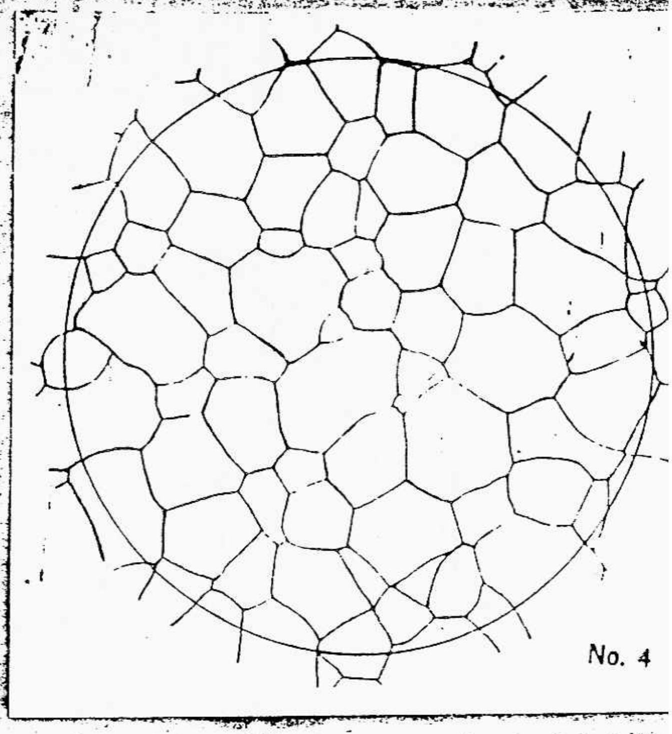

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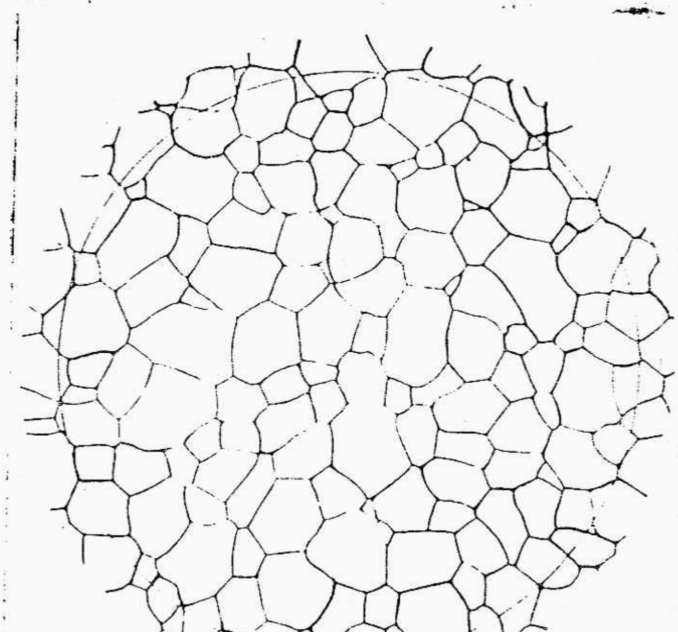

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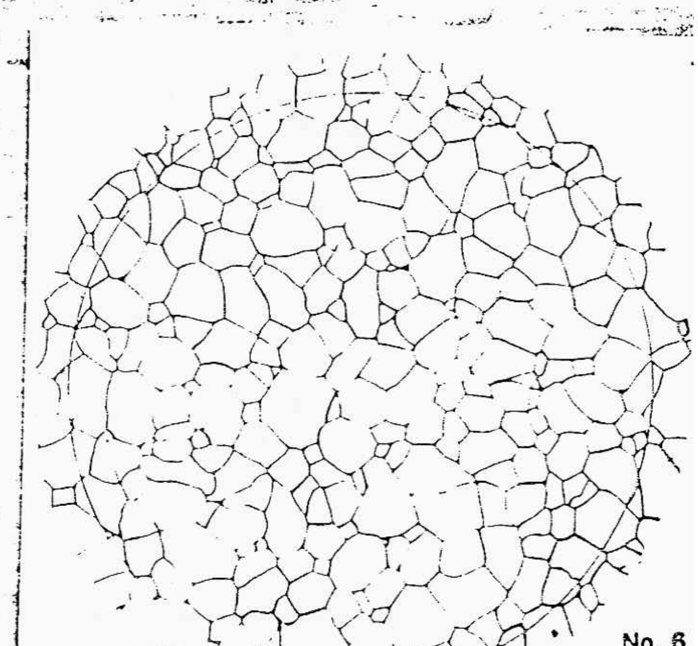

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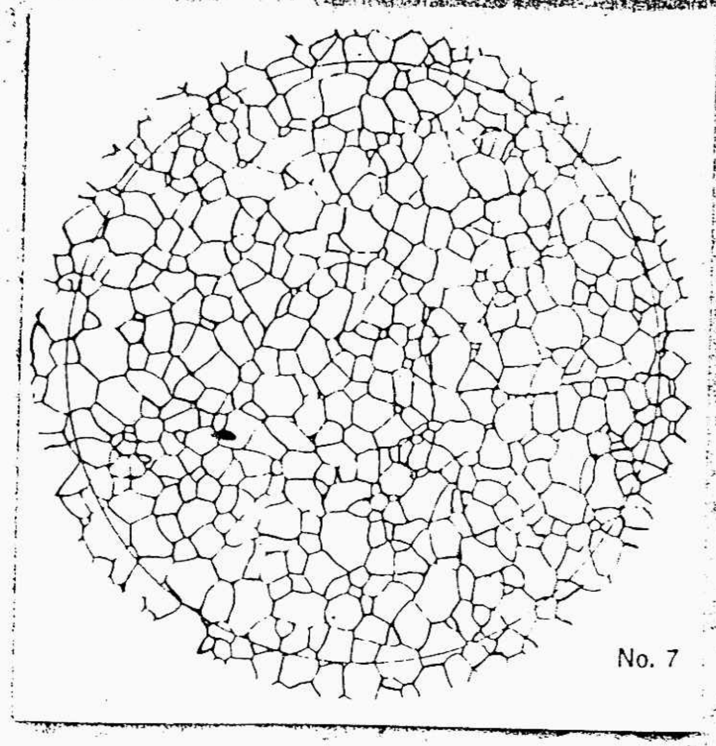
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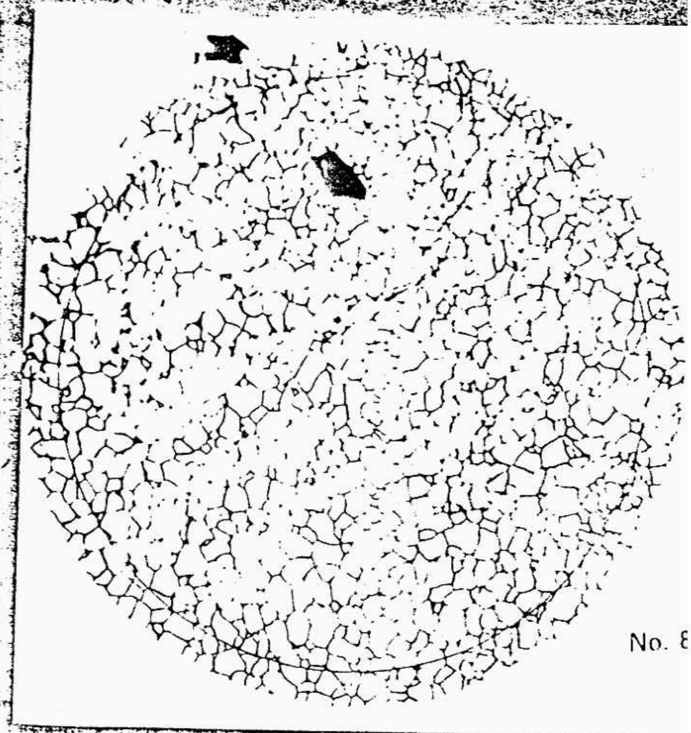
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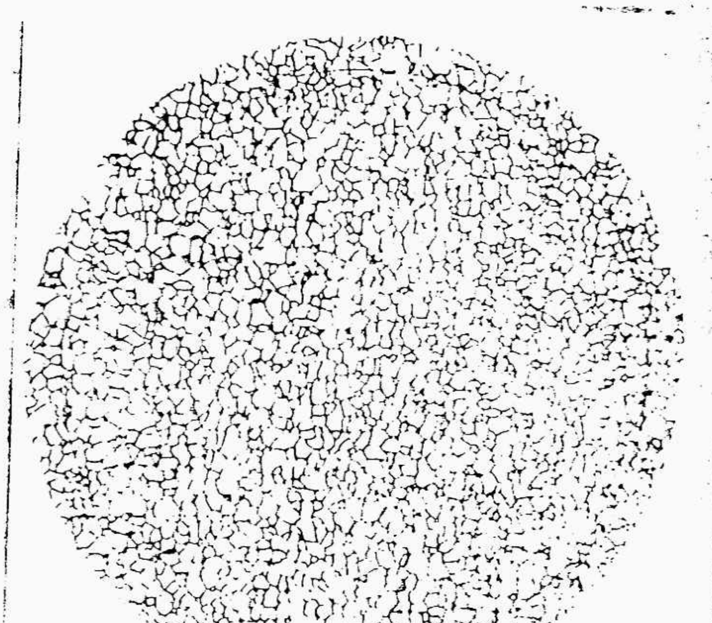
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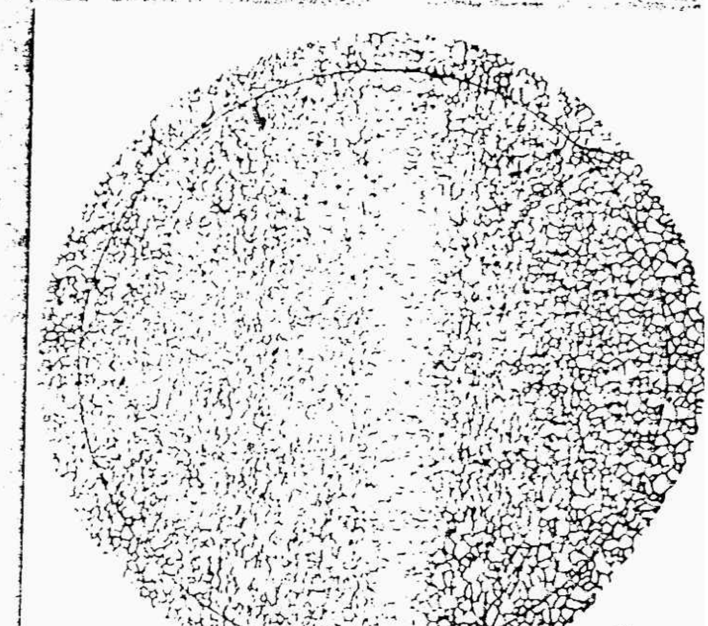
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A

(Sulfide Type)

THIN SERIES
Thickness up to approx. 4 microns (0.00016 in.)

HEAVY SERIES
Thickness approx. 6 microns (0.00025 in.)

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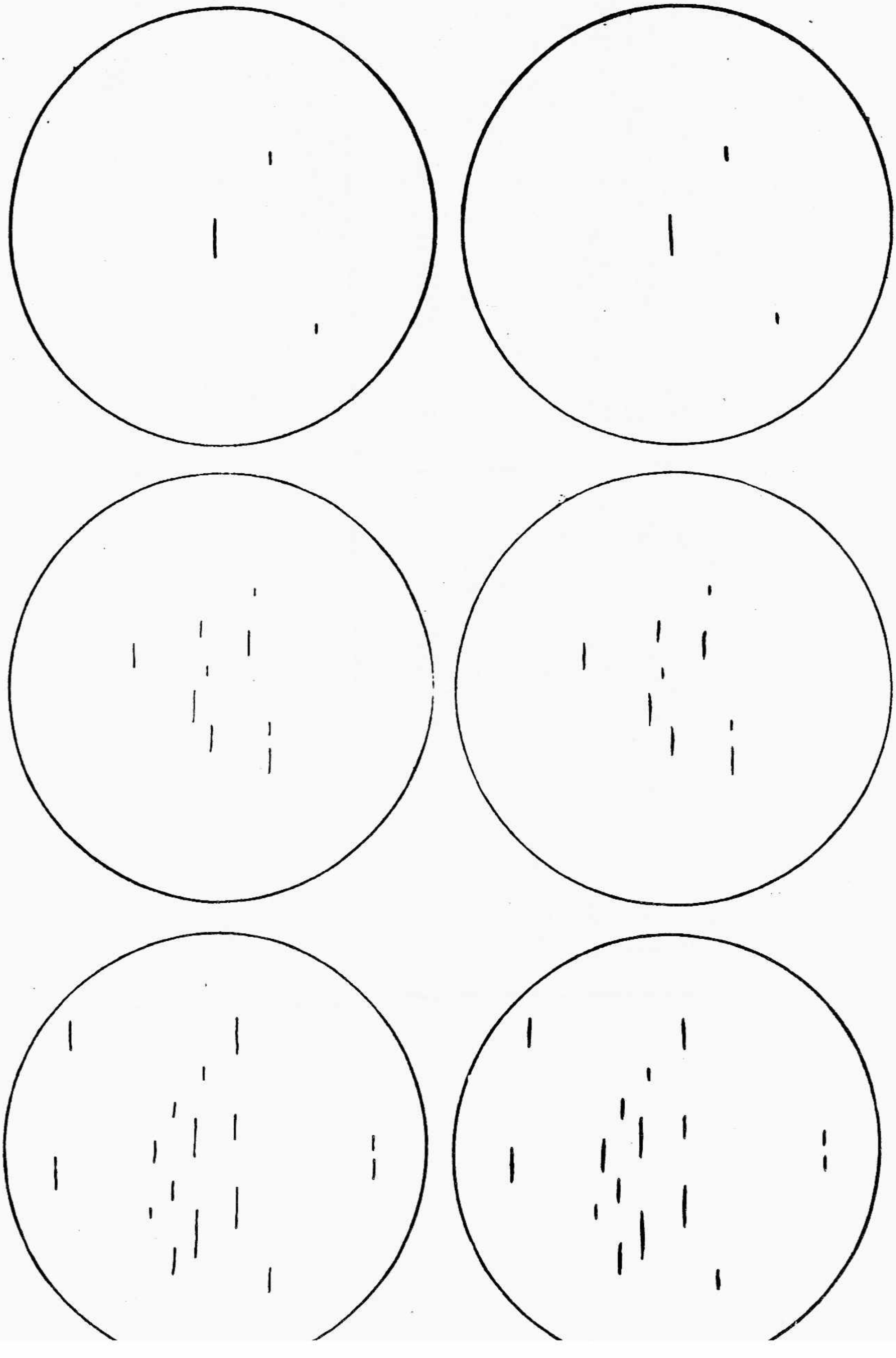

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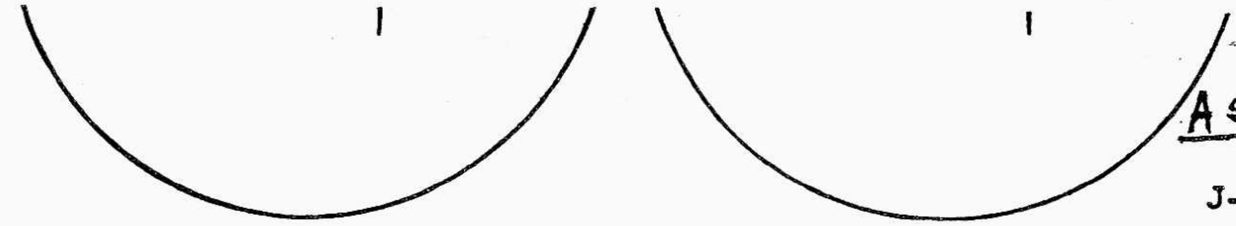

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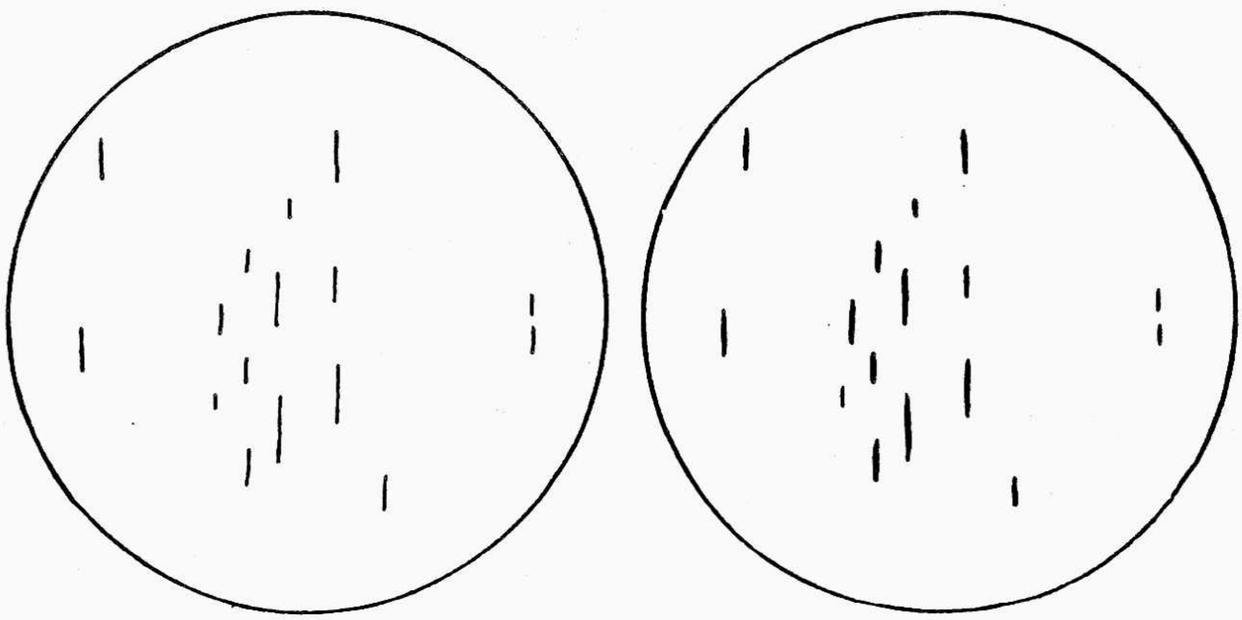

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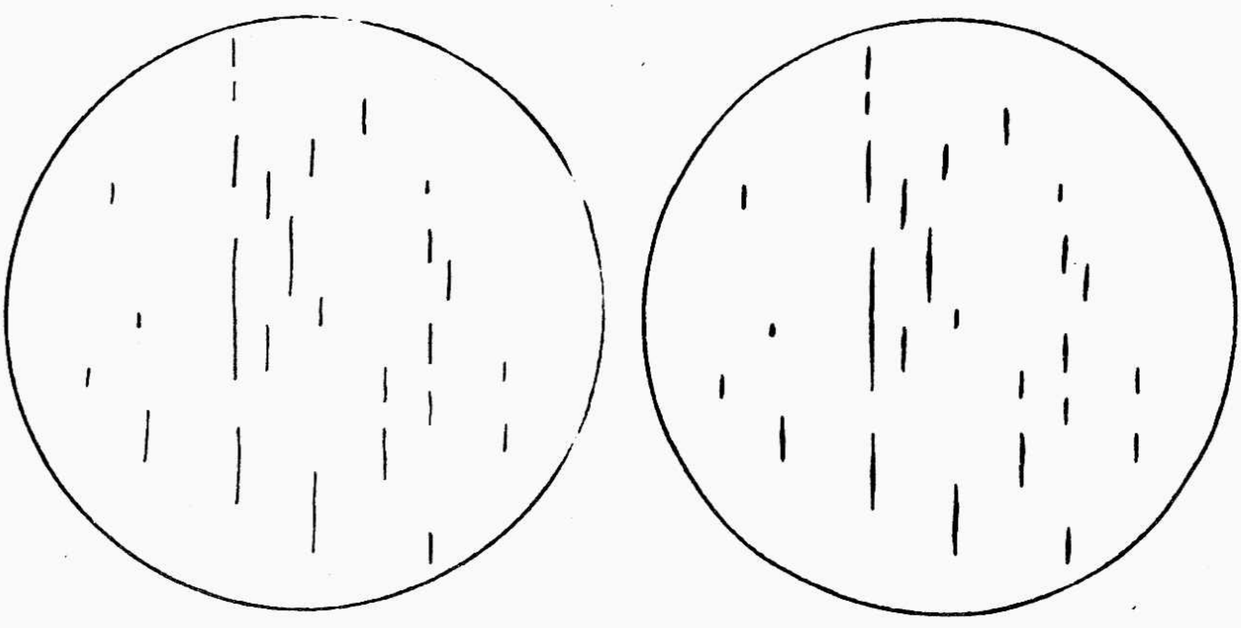

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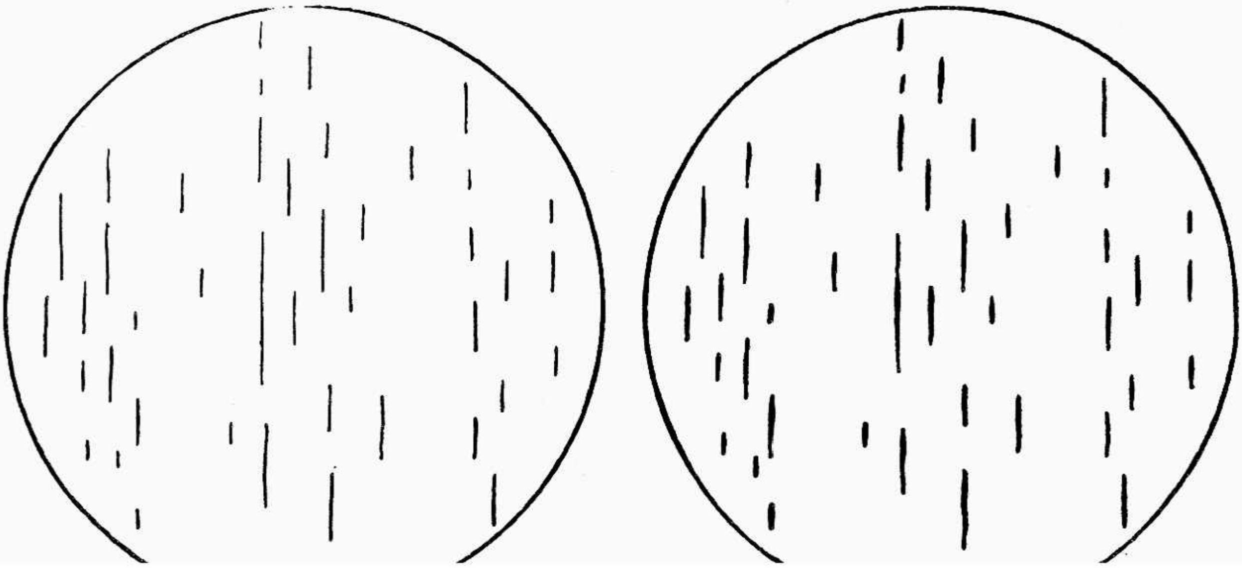
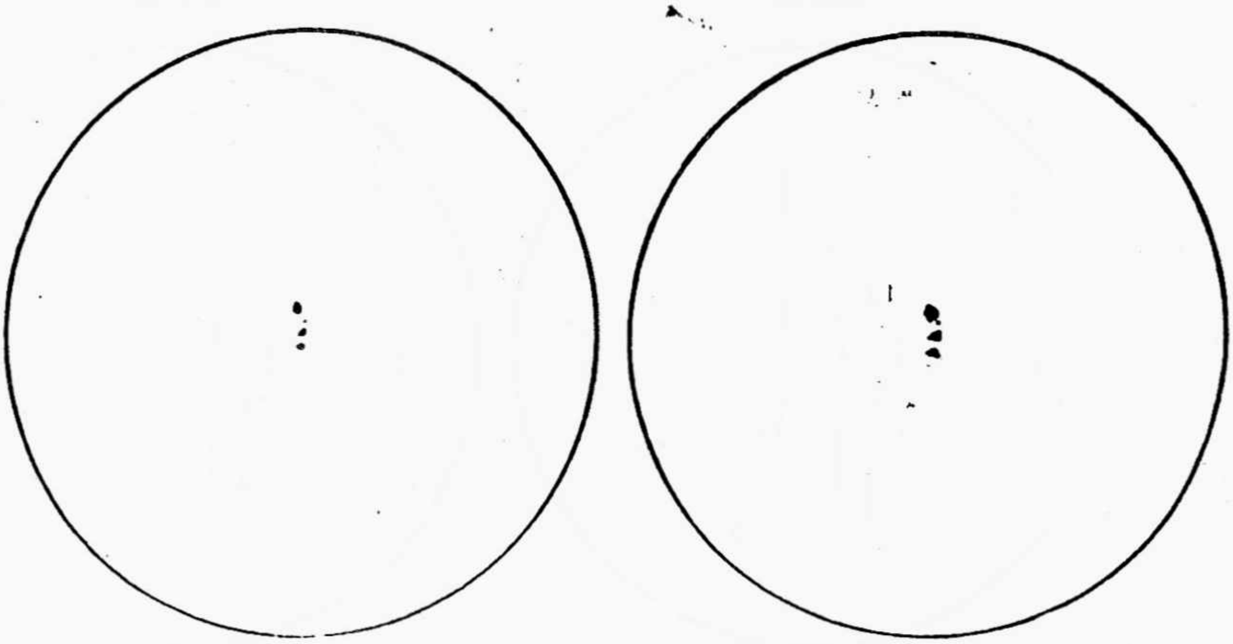


B

(Alumina Type)

THIN SERIES	HEAVY SERIES
Thickness up to approx. 9 microns (0.00035 in.)	Thickness approx. 15 microns (0.0006 in.)



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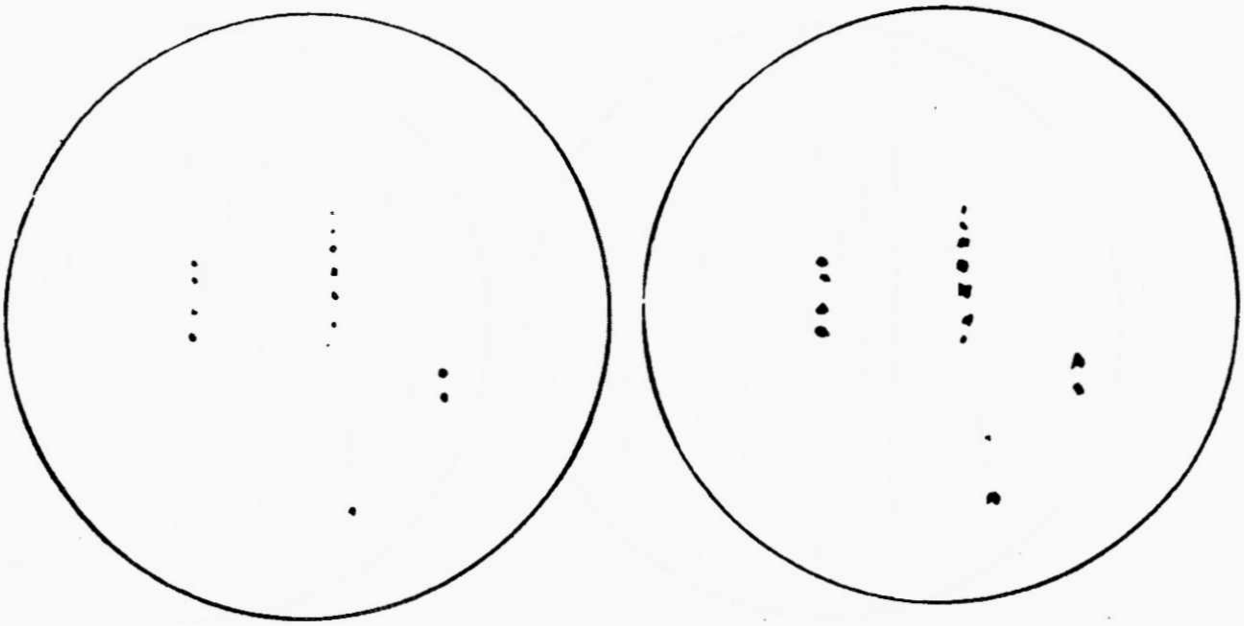

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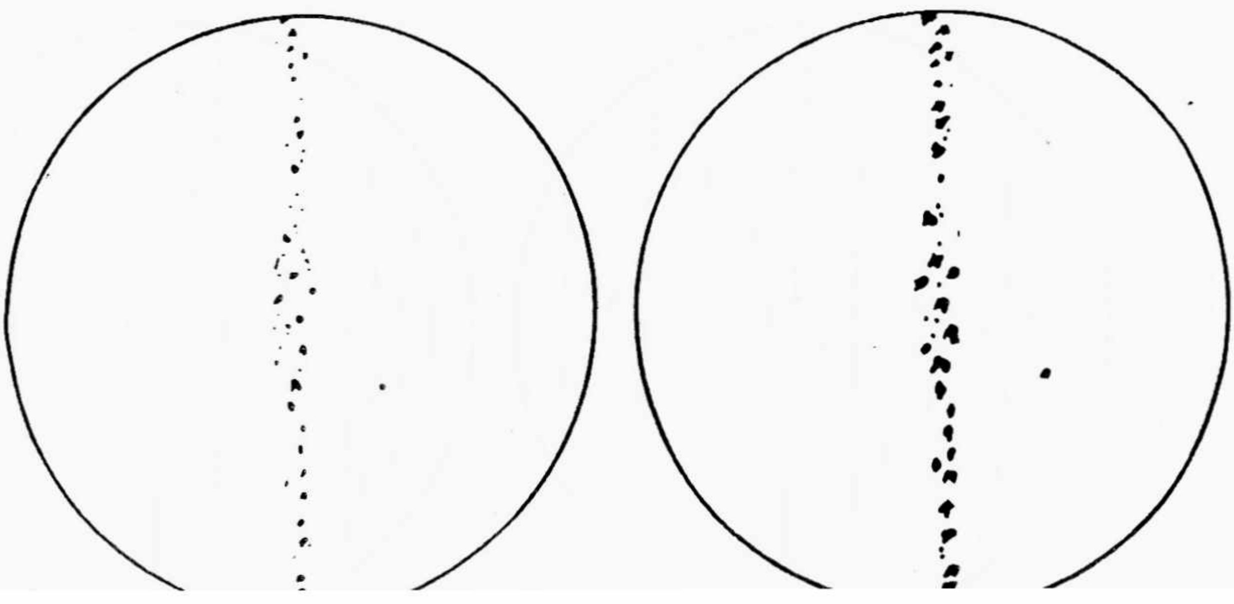

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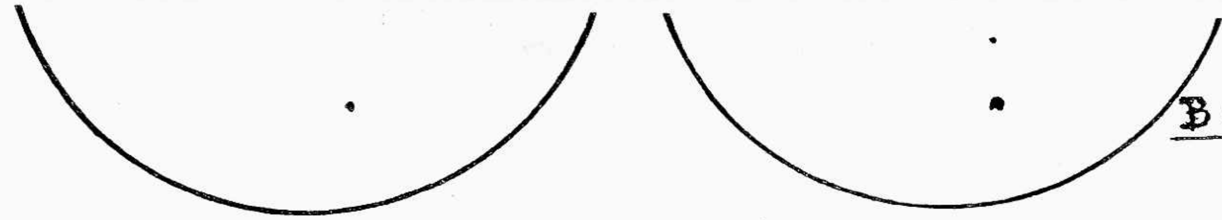

B Alumi

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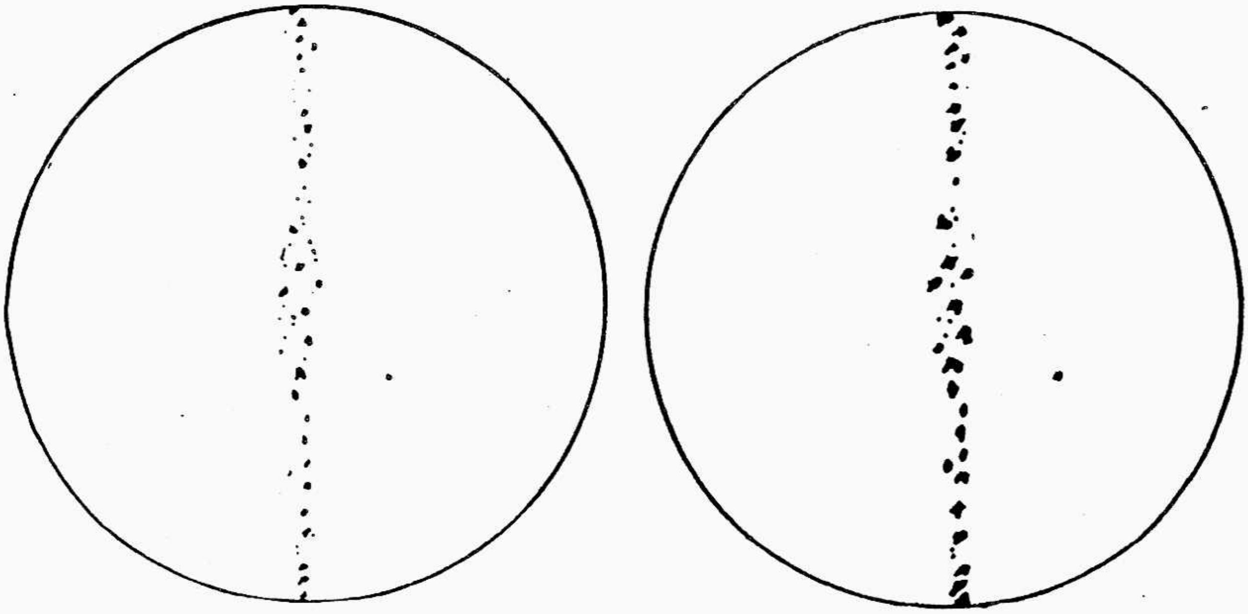

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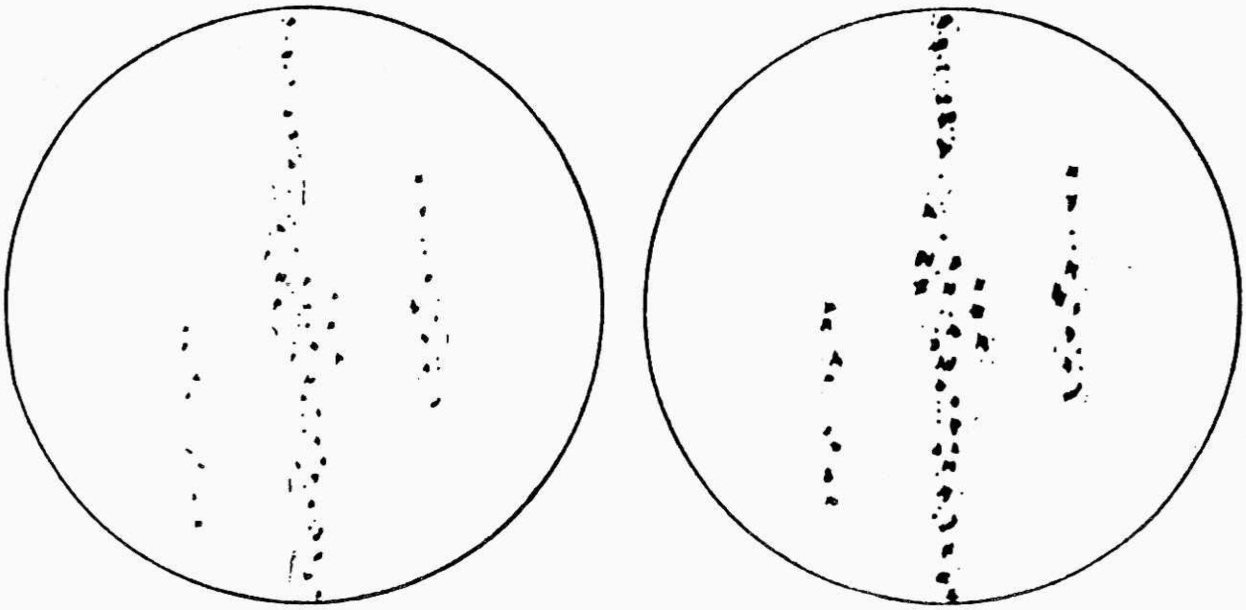

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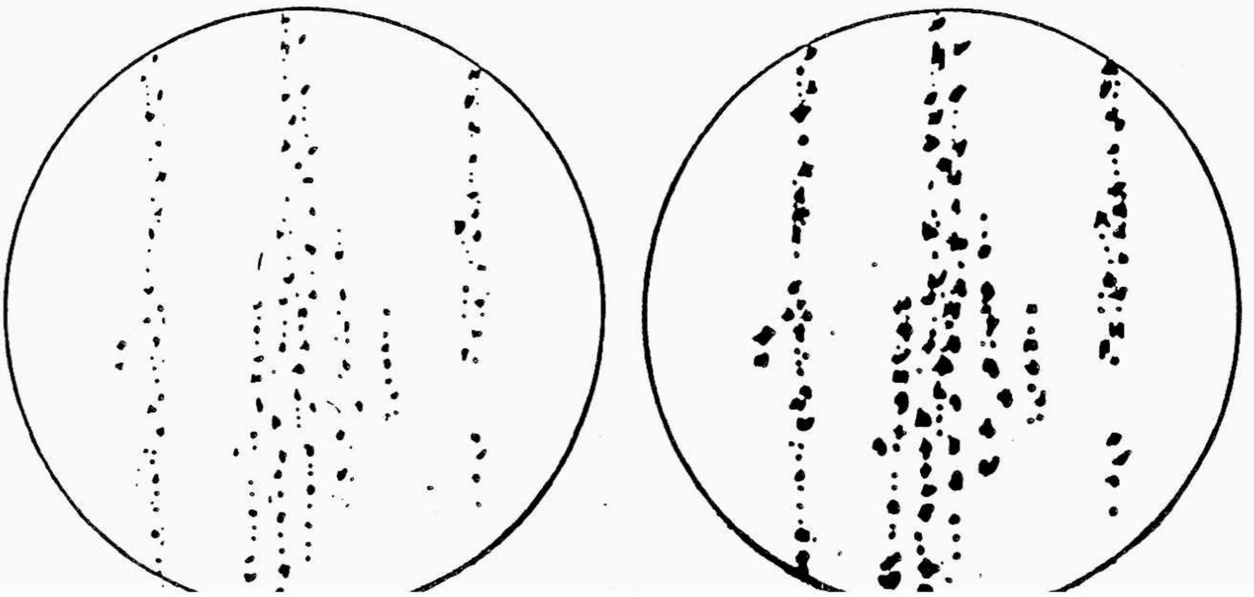

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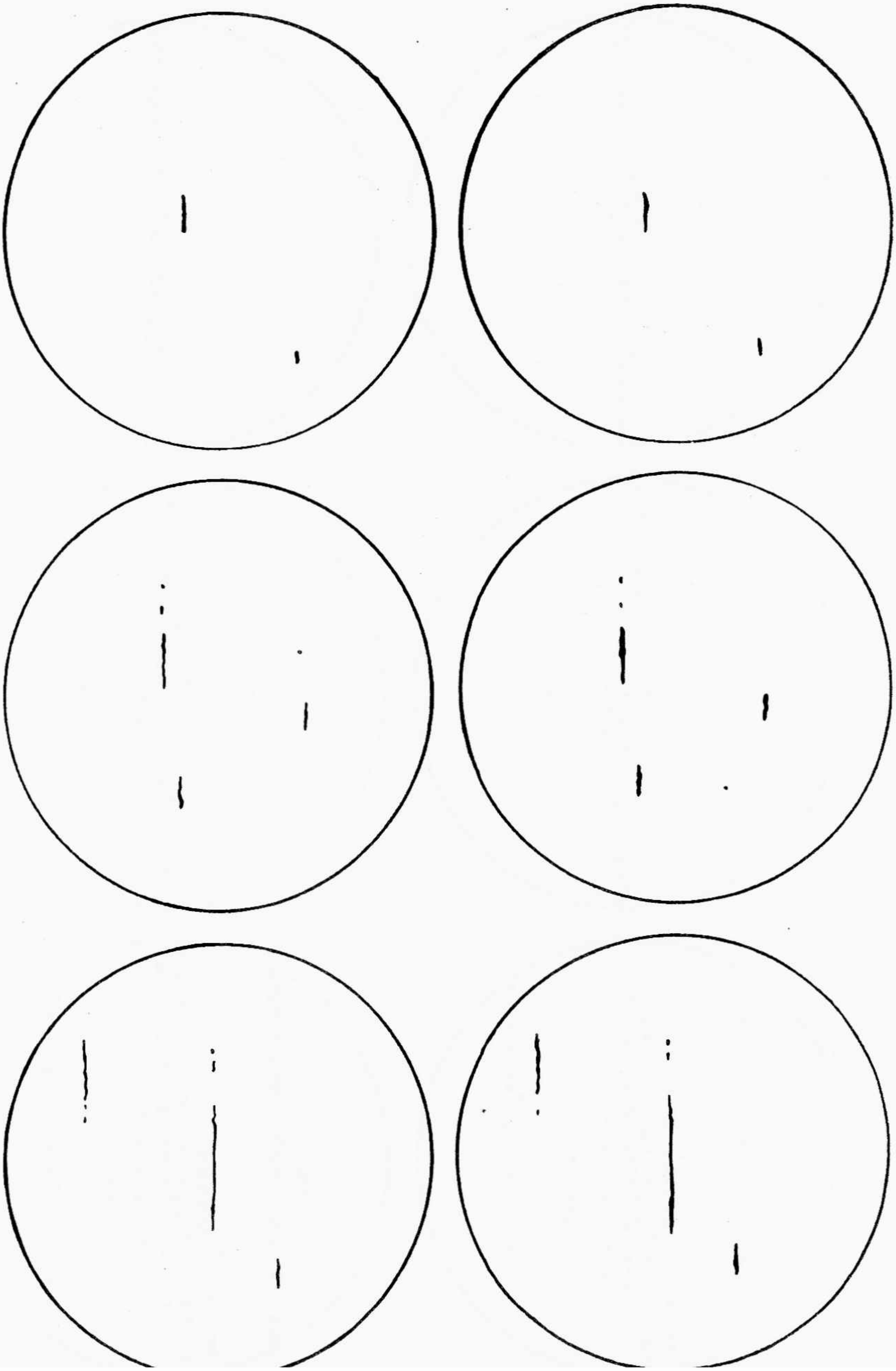
C

(Silicate Type)

THIN SERIES	HEAVY SERIES
Thickness up to approx. 5 microns (0.0002 in.)	Thickness approx. 9 microns (0.00035 in.)



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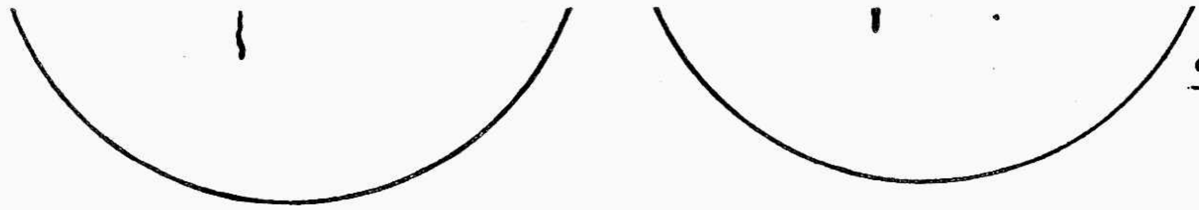

c silic

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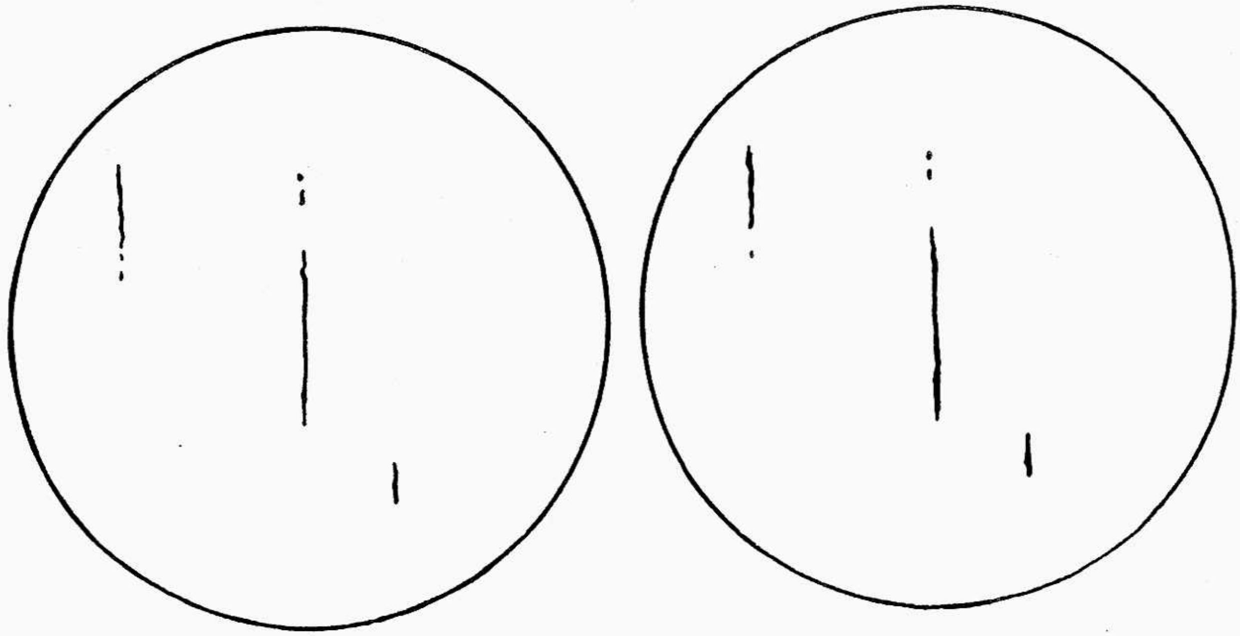

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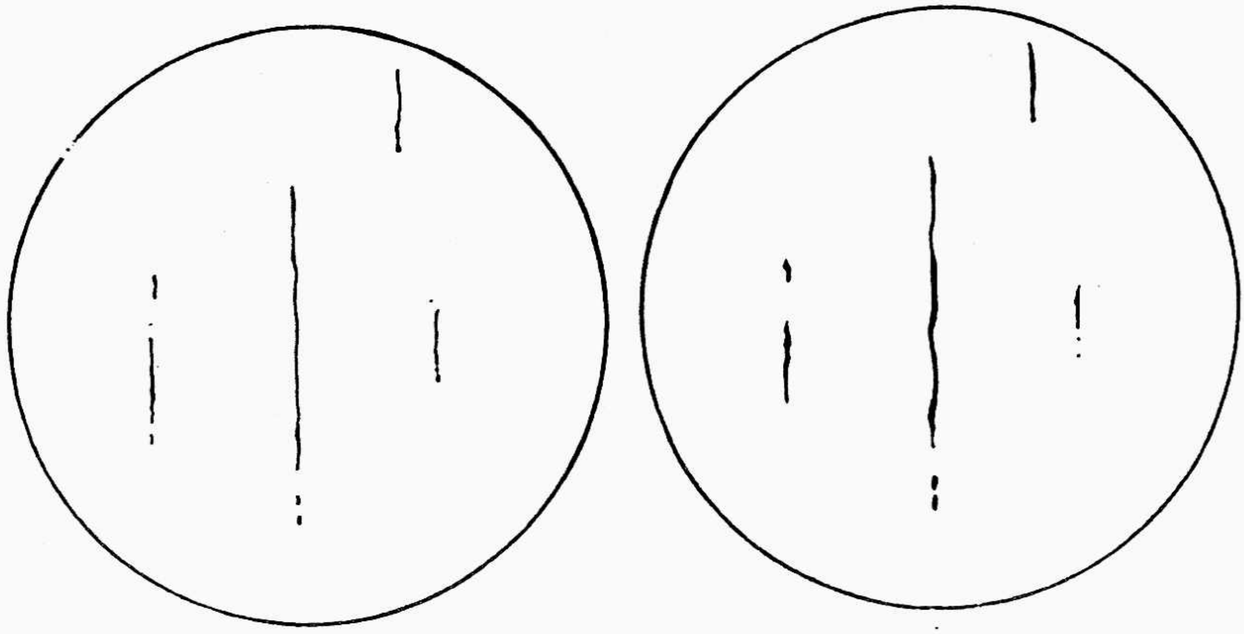

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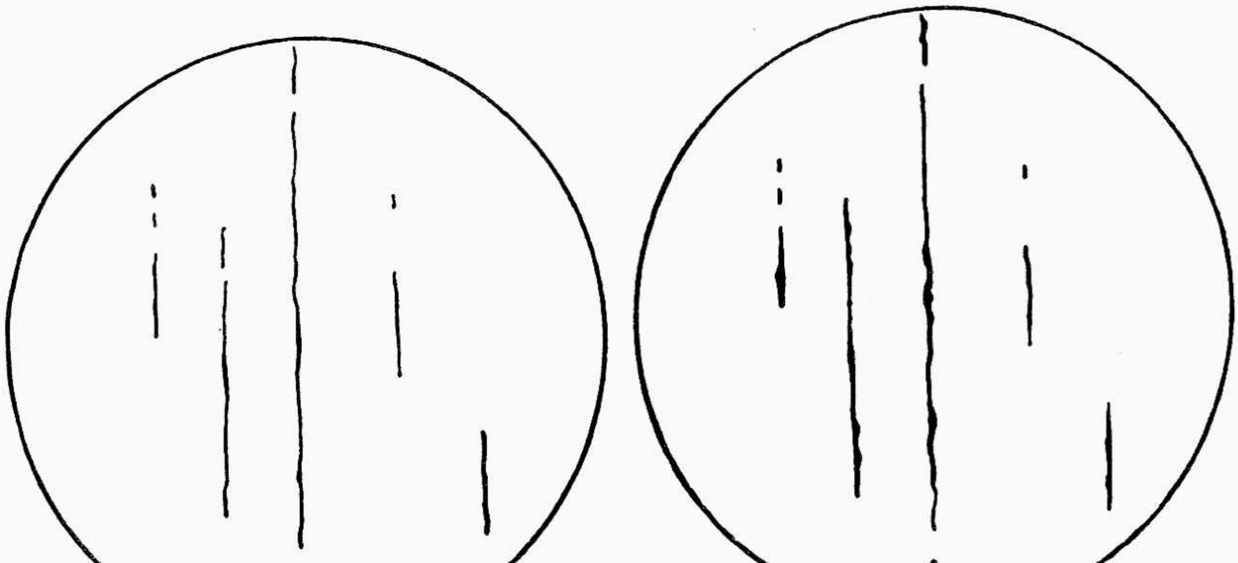

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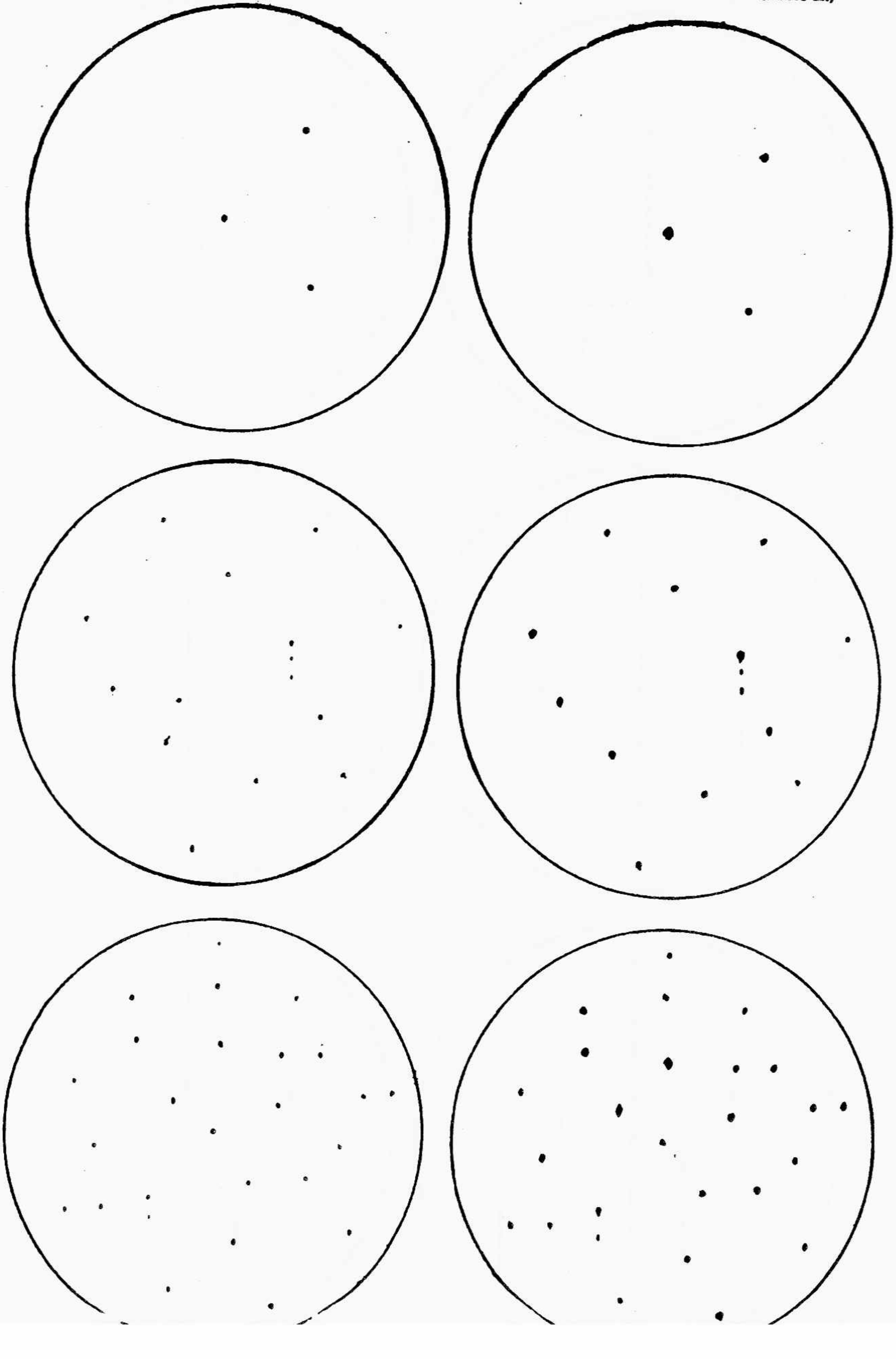
D oxide

[illegible]

THIN SERIES
Thickness up to approx. [illegible] microns ([illegible] in.)

HEAVY SERIES
Thickness approx. [illegible] microns ([illegible] in.)



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D oxfo

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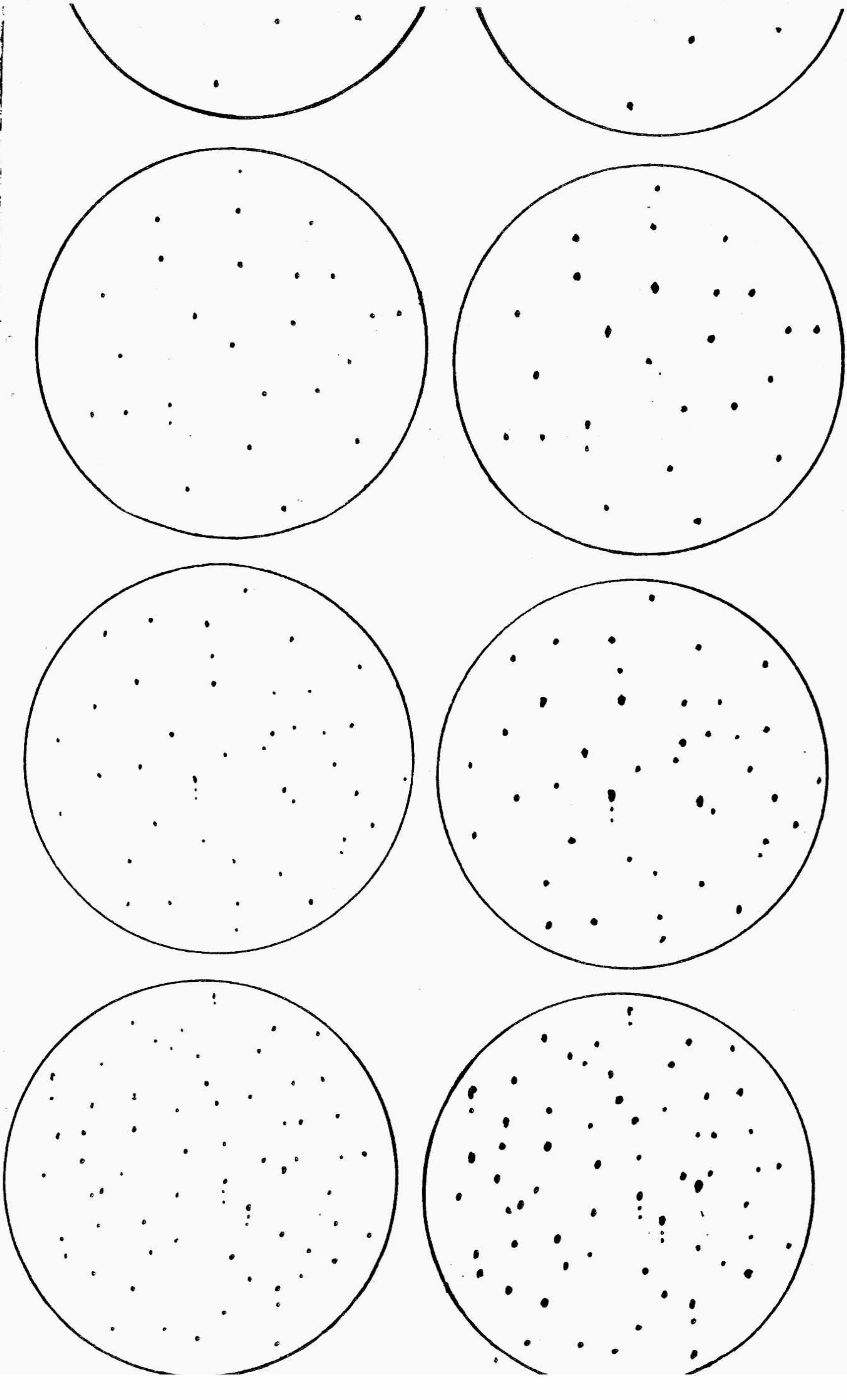

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