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Sylvania Electric Products, Inc.
Bayside, New York

ATOMIC ENERGY COMMISSION
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ABSTRACT

The textures in a hot-pressed uranium rod were investigated after reductions of area were made up to 70%. The texture at 70% reduction of area could best be described as very close to an (041) fiber texture.

TABLE OF CONTENTS

I. INTRODUCTION

A hot-pressed uranium rod was used in the investigation and evaluation of preferred orientation techniques (SEP-88). Since this material was fine-grained and of random orientation it offered an ideal starting material for the examination of textures in rolled uranium rod. The development of preferred orientation with increasing degree of deformation was thus investigated.

II. SPECIMEN PREPARATION

Specimens of rolled uranium rod with various degrees of preferred orientation were prepared as described in detail in SEP-88. The reductions in area were achieved by rolling at 300°C after a ten-minute soak at 300°C at the Argonne National Laboratory. Cross-sectional specimens about 0.150" thick were cut from the rod after 0, 5, 10, 15, 20, 25, 35, 55, and 70% reductions of area. Each specimen was electropolished to remove at least 0.010" from the thickness.

III. EXPERIMENTAL TECHNIQUE

A modification [1,2] of the Schulz reflection preferred orientation technique[3] was used in conjunction with the Geiger counter spectrometer to determine the intensities of planes whose poles were inclined from 0° to 25° to the rolling direction. As stated in SEP-88, it was felt that from a time and material standpoint a cross-sectional specimen would yield sufficiently sensitive indications of preferred orientation since it was felt that in a rod, the planes which were parallel to the rod axis tended to be random about the rod axis, whereas the planes which were parallel to the cross section tended to be parallel to each other. It was therefore felt that examination of the cross section only would yield sufficient data for examining the effect of increasing reductions of area on the texture of a hot-pressed uranium rod.

All specimens were individually mounted on the rotating specimen table of the preferred orientation specimen holder and were integrated by rotation about the rod axis. Data for plotting pole charts were obtained by setting the gonimeter at the proper 2θ value for a given reflection and recording intensities as the position of the cross section was changed with respect to the spectrometer circle. A description of the technique and apparatus is given in references (1) and (2).

Another technique [4] was used to interpret a portion of the data obtained with the modified Schulz technique.

TABLE I

VARIATION OF INTENSITY WITH INCREASING REDUCTION OF AREA

(hkl)	Nominal Per Cent Reduction of Area								
	0	5	10	15	20	25	35	55	70
010	1.4	1.8	2.8	3.6	5.0	4.2	5.3	6.0	5.5
110	19.9	23.2	23.2	24.3	18.4	17.0	15.8	15.3	16.1
021	31.8	35.3	35.5	51.8	53.5	61.3	54.9	57.9	45.0
001	14.0	16.4	16.8	14.1	11.4	10.7	8.8	4.9	3.6
111	16.8	20.2	19.8	17.8	13.8	15.1	14.7	12.3	11.2

IV. RESULTS AND DISCUSSION

In the present investigation, only one uranium rod was examined. The intensity variation at the rolling direction of five reflections with increasing reduction of area is given in Table I.

"D", the per cent deviation from theoretical intensity, as a function of reduction of area is plotted in Figs. 1-3. "D" is defined as $(R_0-R_T)/R_0$ where R_0 is the observed intensity ratio and R_T is the theoretical intensity ratio. It is seen from these curves as well as from Fig. 4, a plot of the intensity variation of the five examined reflections as a function of increasing reduction of area, that there is an apparent tendency toward a duplex fiber texture with the (010) and (021) poles parallel to the rod axis. This apparent duplex texture could result from a wide scatter about the mean orientations of an (010) fiber texture, especially at low deformations, since the angle between an (021) and (010) pole is 31°. The similarity between (021) and (010) curves of Figs. 1-4 (up to 60% reduction of area) lends further support to the contention that the (021) intensity maximum at the rolling direction is most probably caused by the above mentioned scatter about the mean (010) pole positions. At 70% reduction of area, both (010) and (021) intensity maxima at the rolling direction begin to decrease. This decrease can be attributed to an (041) fiber texture (to be discussed below) in which the (010) pole is 15-1/2° to the rod axis.

The pole charts of Figs. 5-9 summarize the variation of intensities of the different reflections as a function of the tilting angle ϕ [1,2]. Background intensity has been subtracted and the proper tilting angle correction [1] applied.

IV. RESULTS AND DISCUSSION (Cont'd.)

The (111) pole chart exhibits first an increase in intensity at low reductions of area, and then a decrease in intensity at higher reductions in all examined regions of the pole chart up to 70% reduction of area. This might indicate the possibility of a compression texture in the as-hot-pressed rod. At 70% reduction of area, the (111) intensity maximum lies outside the range of ϕ values investigated.

It is seen from the (010) pole chart that the concentration of (010) poles increases in all examined areas of the pole chart with increasing reduction of area. At 70% reduction of area, there is a tendency toward alignment of the (010) poles 15° from the rod axis.

The (021) pole chart indicates an increase in concentration of (021) poles in all examined areas of the pole chart with increasing reduction of area up to 70%. At 70% reduction there is a tendency for (021) poles to be aligned 15° to the rod axis.

The (001) pole chart reveals a tendency toward a decrease in intensity with increasing reduction of area. At 70% reduction of area, the (001) maximum is outside the range of ϕ angles investigated. It should be noted that the as-hot-pressed rod reveals a tendency for (001) poles to be aligned about 6° to the rod axis, another indication of the possibility of a slight compression texture.

The (110) pole chart reveals a tendency for (110) poles to be aligned in the vicinity of the rod axis for deformations up to 15%. At higher deformations, the tendency is for the (110) poles to exhibit intensity maxima in the ϕ angle range of 20 to 25° and possibly outside the range of ϕ values investigated. At 70% reduction of area, there is an indication of an intensity maximum outside the range of ϕ angles investigated. It has been proposed [5] that working uranium at $300^\circ C$ produces a duplex (010), (110) fiber texture and that as soon as the (110) poles become parallel to the rod axis they would be favorably oriented for twinning on the (130) plane. (130) twinning would cause a marked decrease in the (110) component and a corresponding increase in the (010) component. It is possible that (130) twinning is responsible for the decrease in the initial tendency of (110) poles to lie in the vicinity of the rod axis and contributes toward the increase in the tendency for (010) poles to lie in the vicinity of the rod axis as the deformation is increased.

Fig. 10 illustrates a possible grain orientation which is compatible with the textures reported above for a uranium rod which had a 70% reduction of area by rolling at $300^\circ C$. The (100) plane is the plane of the drawing. It is seen from this drawing that both the (010) and (021) poles are inclined $15\text{-}1/2^\circ$ to the rod axis. This corresponds closely to an (041) fiber texture. Fig. 11 is a mean orientation pole figure compatible with the texture shown in Fig. 10.

V. TEXTURES OF BETA-TREATED MATERIAL

A beta-treated rod was examined at the Argonne National Laboratory. The grain size in this rod varied from 0.09 to 0.30mm from outer surface to core respectively. It was felt that examination of ten or more cross sections of this rod might yield sufficient information to indicate the type of texture present in this rod even in the presence of a large grain size. Table II summarizes the intensities of the reflections from three cross sections of this rod. It is obvious from this table that there is no resemblance of consistency in the data, indicating that it is not possible to determine the texture in this material by examining one section alone, even with integration. Statistically, it would probably be necessary to examine in the order of ten or more cross sections and an average of the intensities obtained from these ten sections might then be a measure of the average throughout the rod. It is interesting to note that averaging as few as three cross sections yield intensity ratios approaching those of a theoretically random rod. Neither the deviation from theoretical nor the approach toward theoretical ratios is deemed significant of the presence or absence of a texture in this material since only three cross sections were examined.

TABLE II

INTENSITIES OF LOW INDEX

REFLECTIONS AT $\phi = 0^{o}$ IN BETA-TREATED MATERIAL

(hkl)	Cross-Section # 1	2	3	Average	Theoretical
(010)	1.3	2.9	0.2	1.47	-
(110)	25.7	31.3	17.7	24.9	-
(021)	4.6	67.8	7.1	26.5	-
(001)	32.9	5.4	6.4	14.9	-
$\frac{(010)}{(001)}$	-	-	-	.099	.107
$\frac{110}{001}$	-	-	-	1.67	1.43
$\frac{021}{001}$	-	-	-	1.77	2.05

VI. CONCLUSIONS

A. The texture of the rolled rod which had a 70% reduction of area at 300°C could best be described as an (041) fiber texture with the (100) pole perpendicular to the rod axis and the (001), (021) and (010) poles 74-1/2°, 15-1/2° and 15-1/2° respectively from the rod axis.

B. The possibility exists that there is a slight compression texture in hot-pressed uranium rods in the as-hot-pressed condition.

C. Examination of three cross sections of a beta-treated rod revealed inconclusive evidence of the absence or presence of preferred orientation, but strongly indicated an inhomogeneity of preferred orientations along the length of the rod.

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2. W. P. Chernock and P. A. Beck, pp. 73-98, TID-5061, January 31, 1952
3. L. G. Schulz, J. Applied Physics, 20, 1030 (1949)

5. KAPL-370, June 1950

Fig. 1 Percent Deviation of Intensity Ratios as a Function of Percent Reduction of Area at 300°C (111) Base Plane at $\phi = 0°$

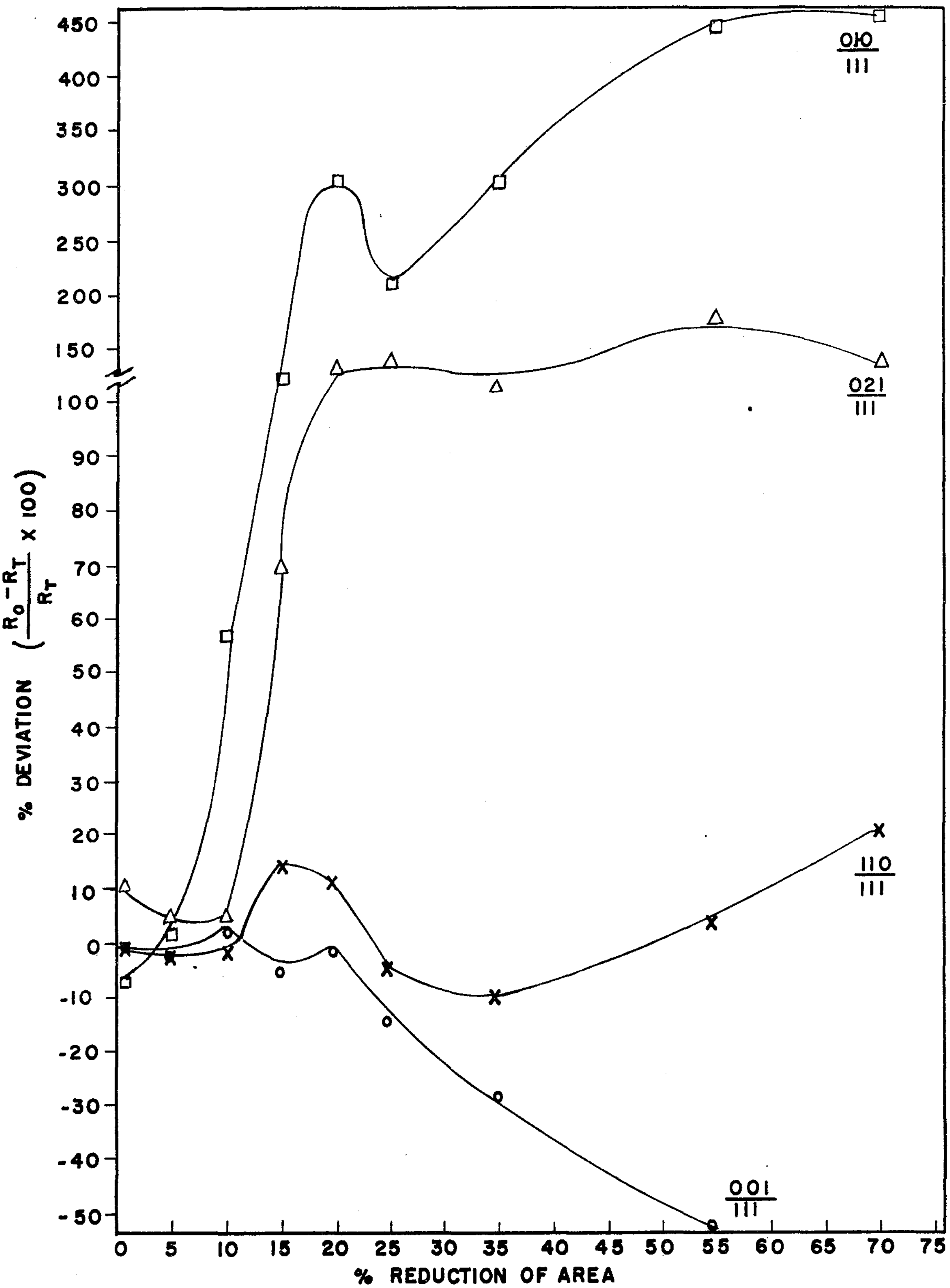


Fig. 2 Percent Deviation of Intensity Ratios as a Function of Percent Reduction of Area at 300°C (001) Base Plane at $\phi = 0°$

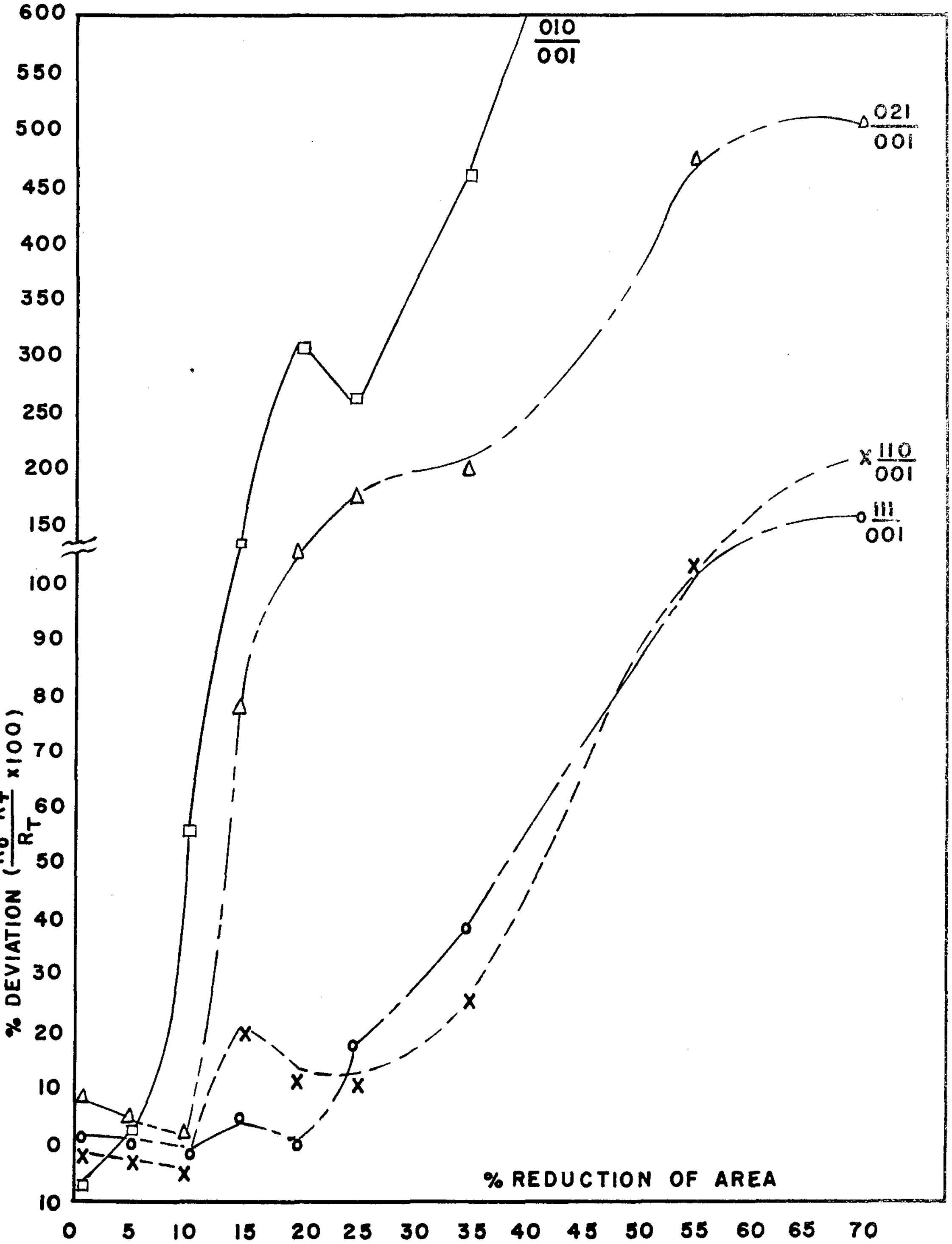
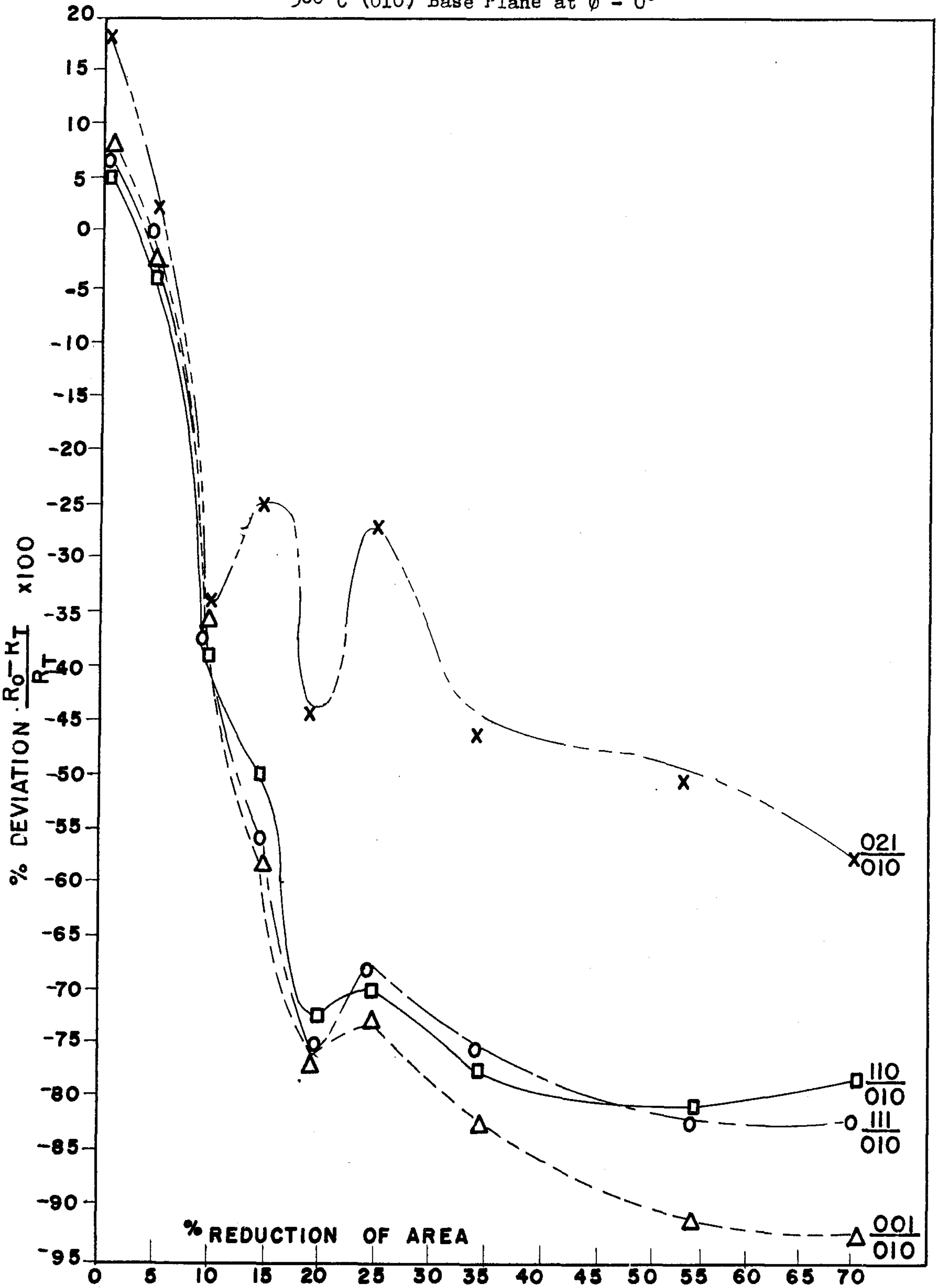


Fig. 3 Percent Deviation of Intensity Ratios as a Function of Percent Reduction of Area at 300°C (010) Base Plane at $\phi = 0°$



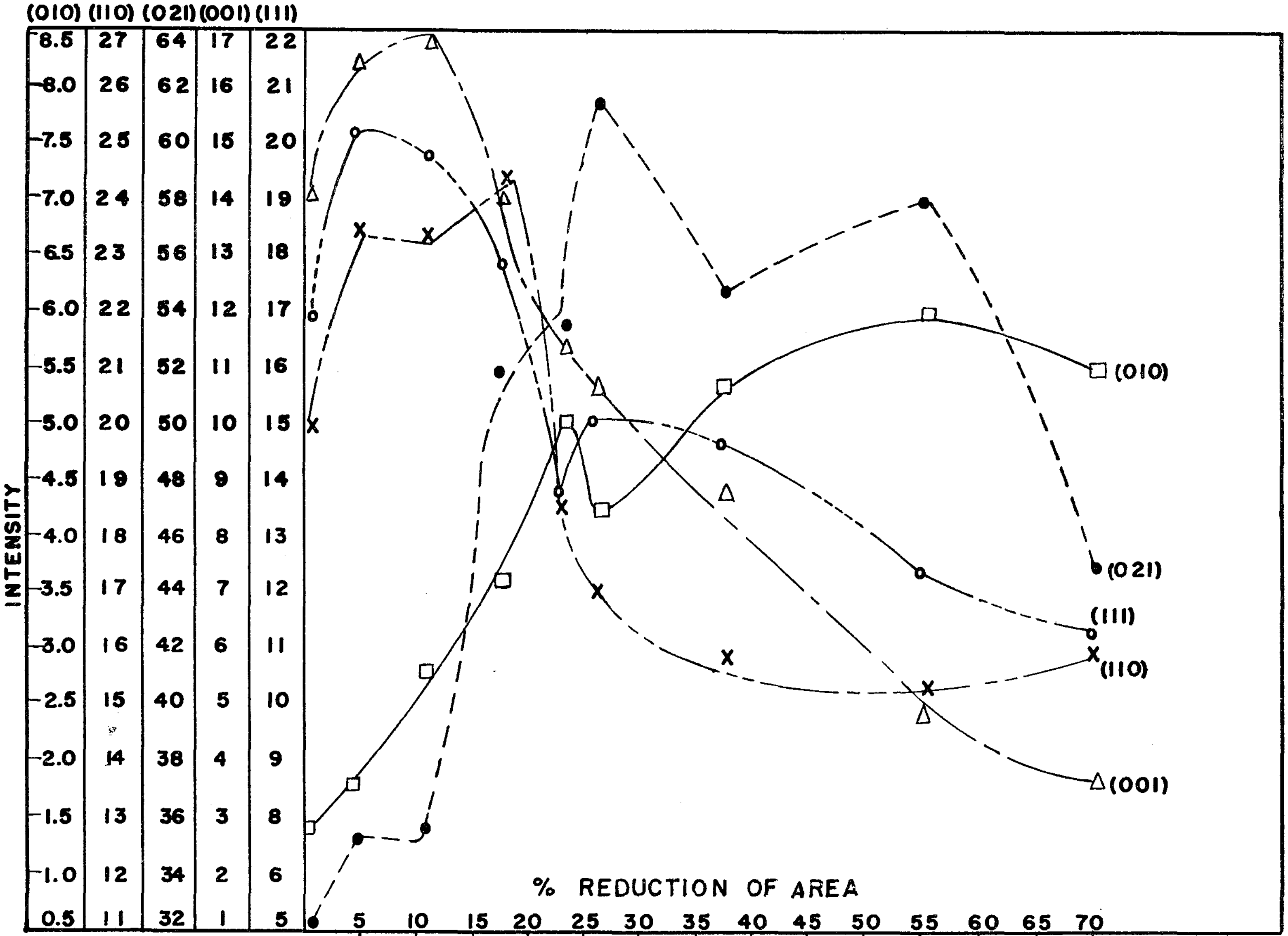


Fig. 4 Variation of Intensity With Percent Reduction of Area at 300°C at $\phi = 0^{\circ}$

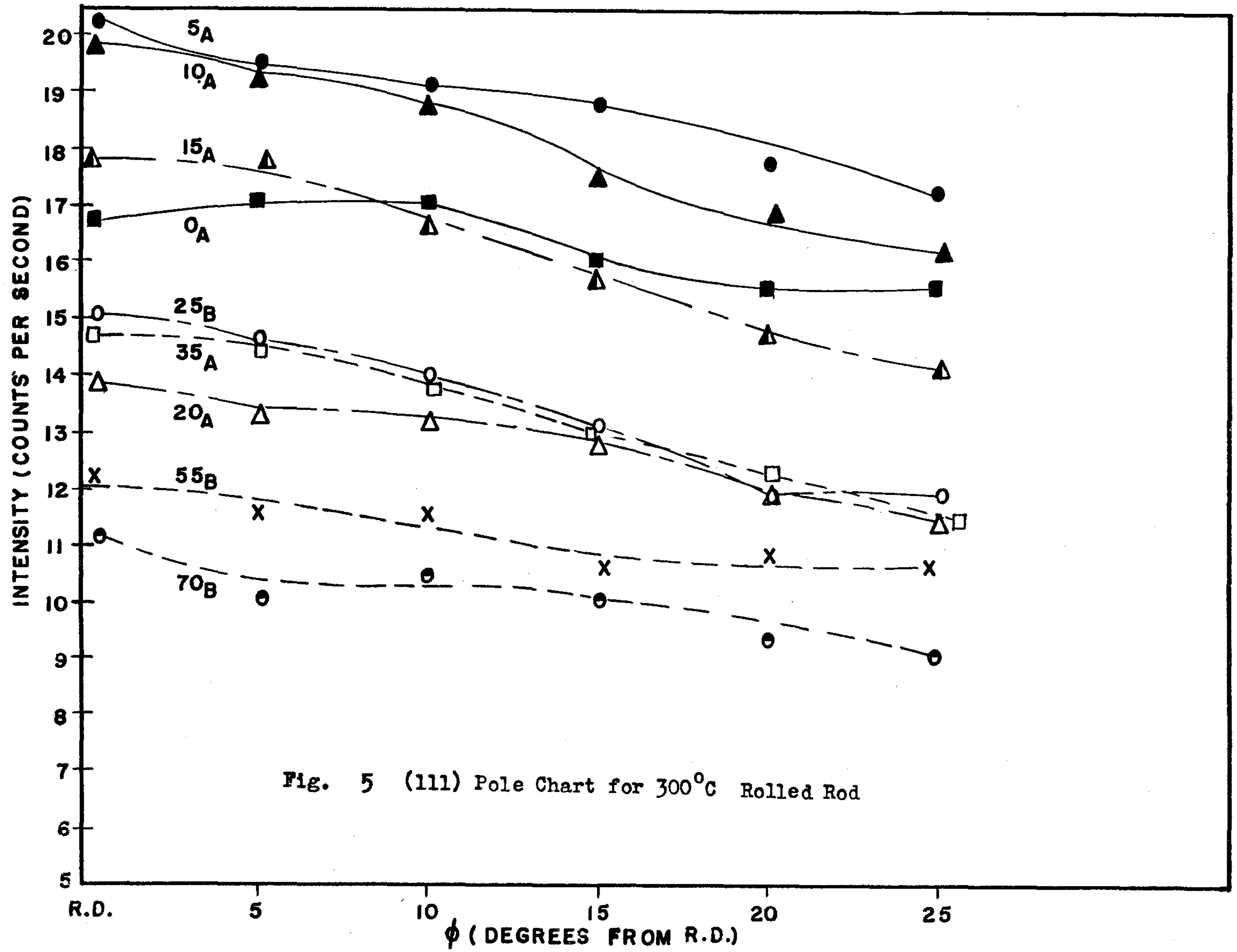


Fig. 5 (111) Pole Chart for 300°C Rolled Rod

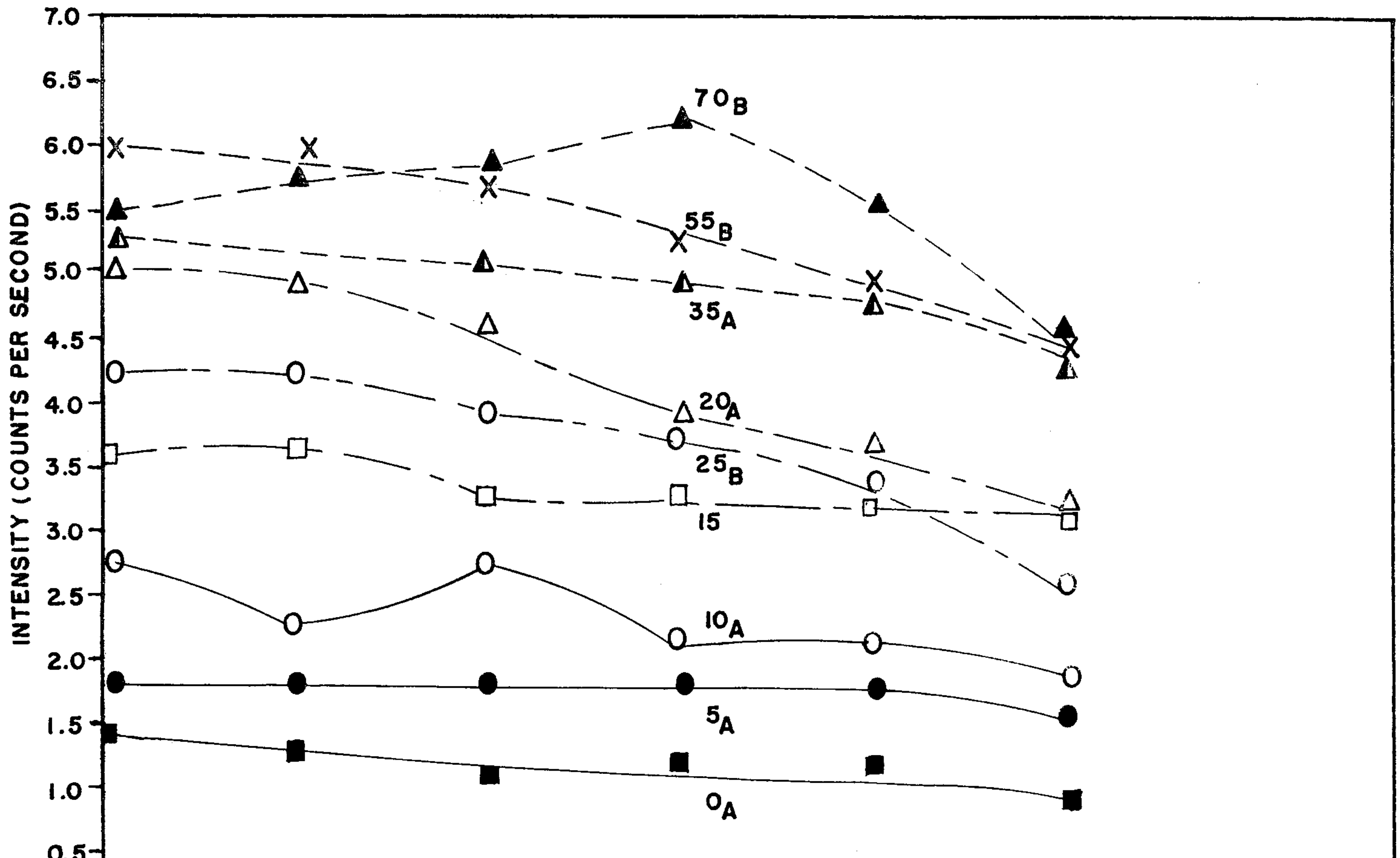


Fig. 6 (010) Pole Chart for 300°C Rolled Rod

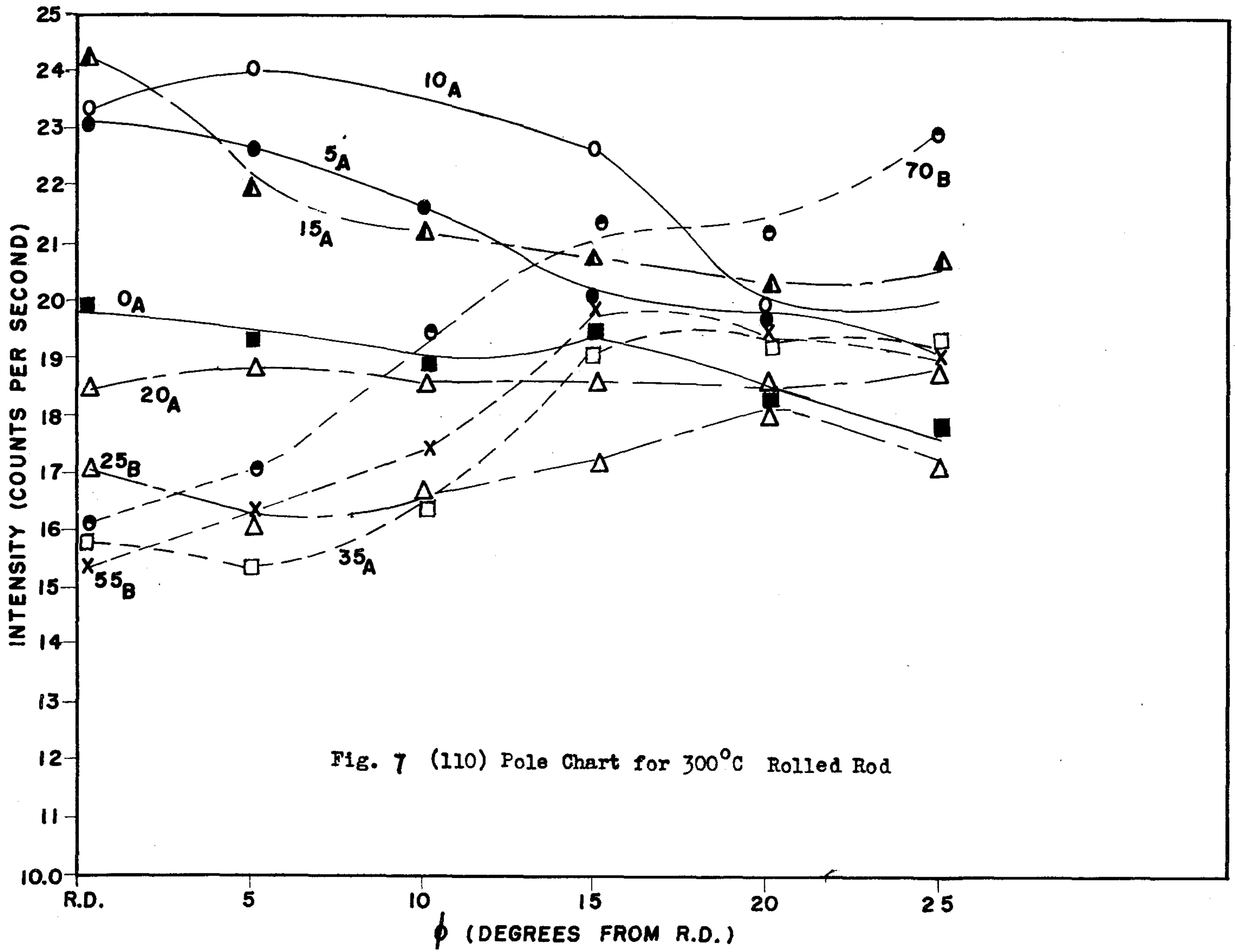


Fig. 7 (110) Pole Chart for 300°C Rolled Rod

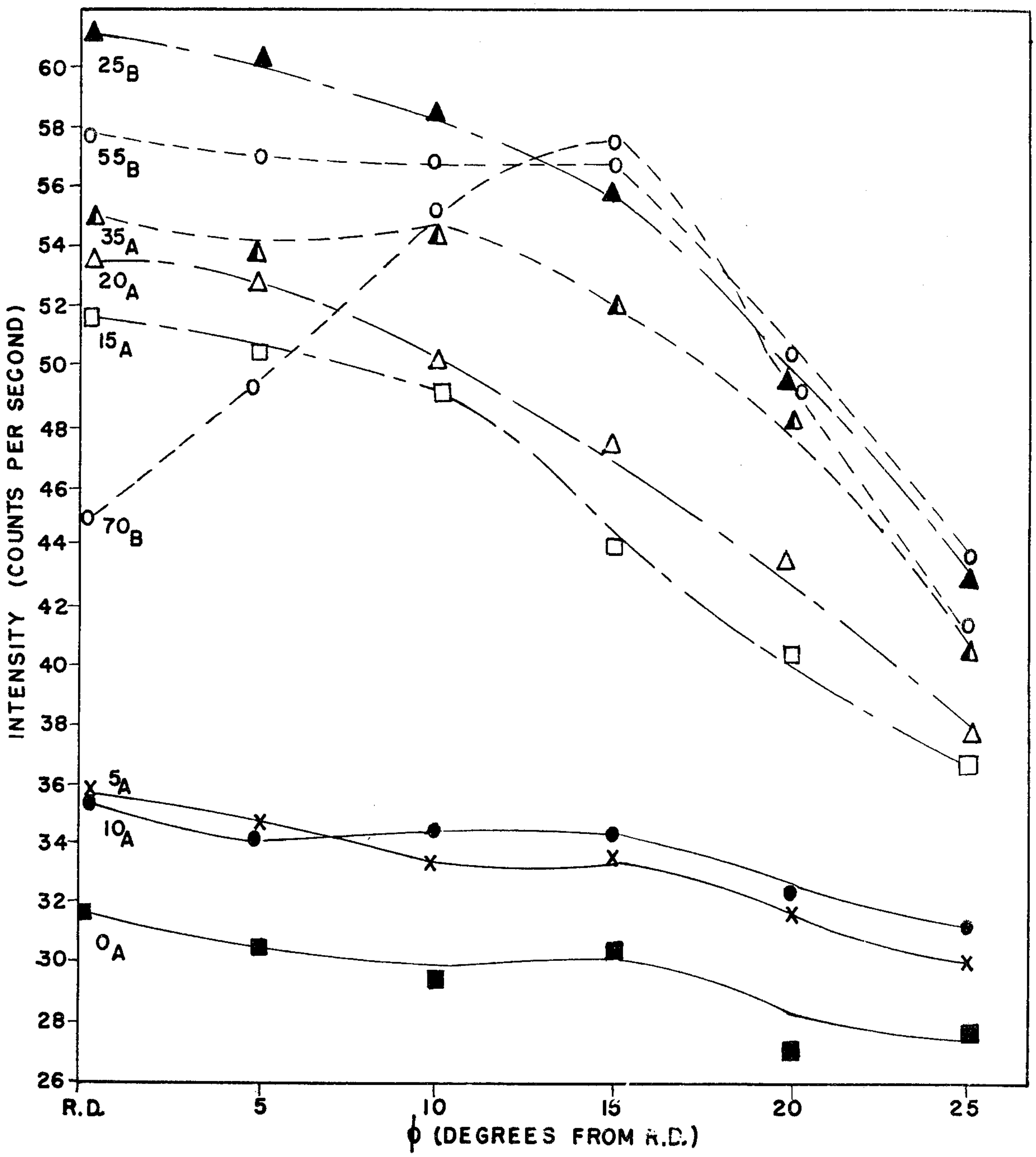


Fig. 8 (021) Pole Chart for 300°C Rolled Rod

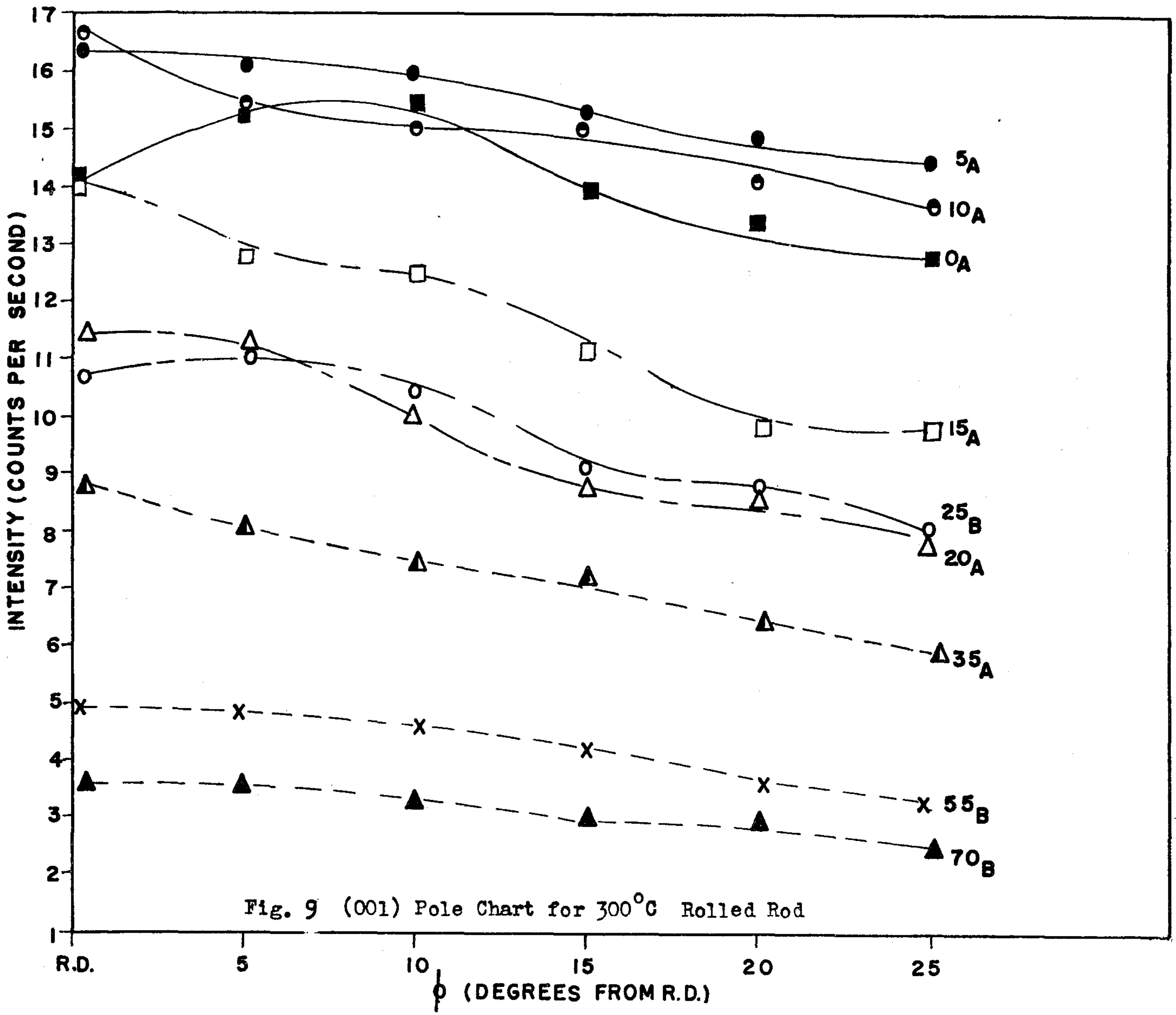


Fig. 9 (001) Pole Chart for 300°C Rolled Rod

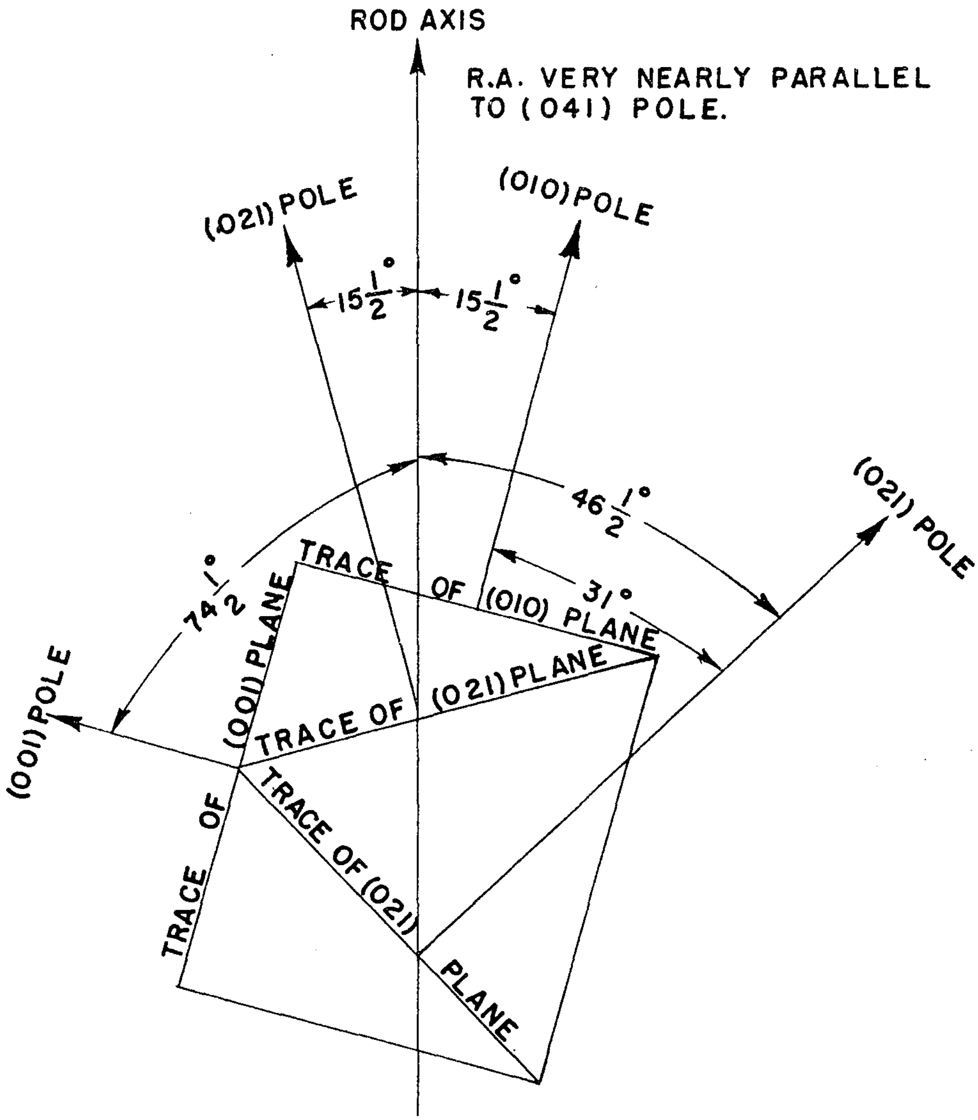


Fig. 10 Texture in Hot Pressed Rod After 70% R. A. at 300°C.

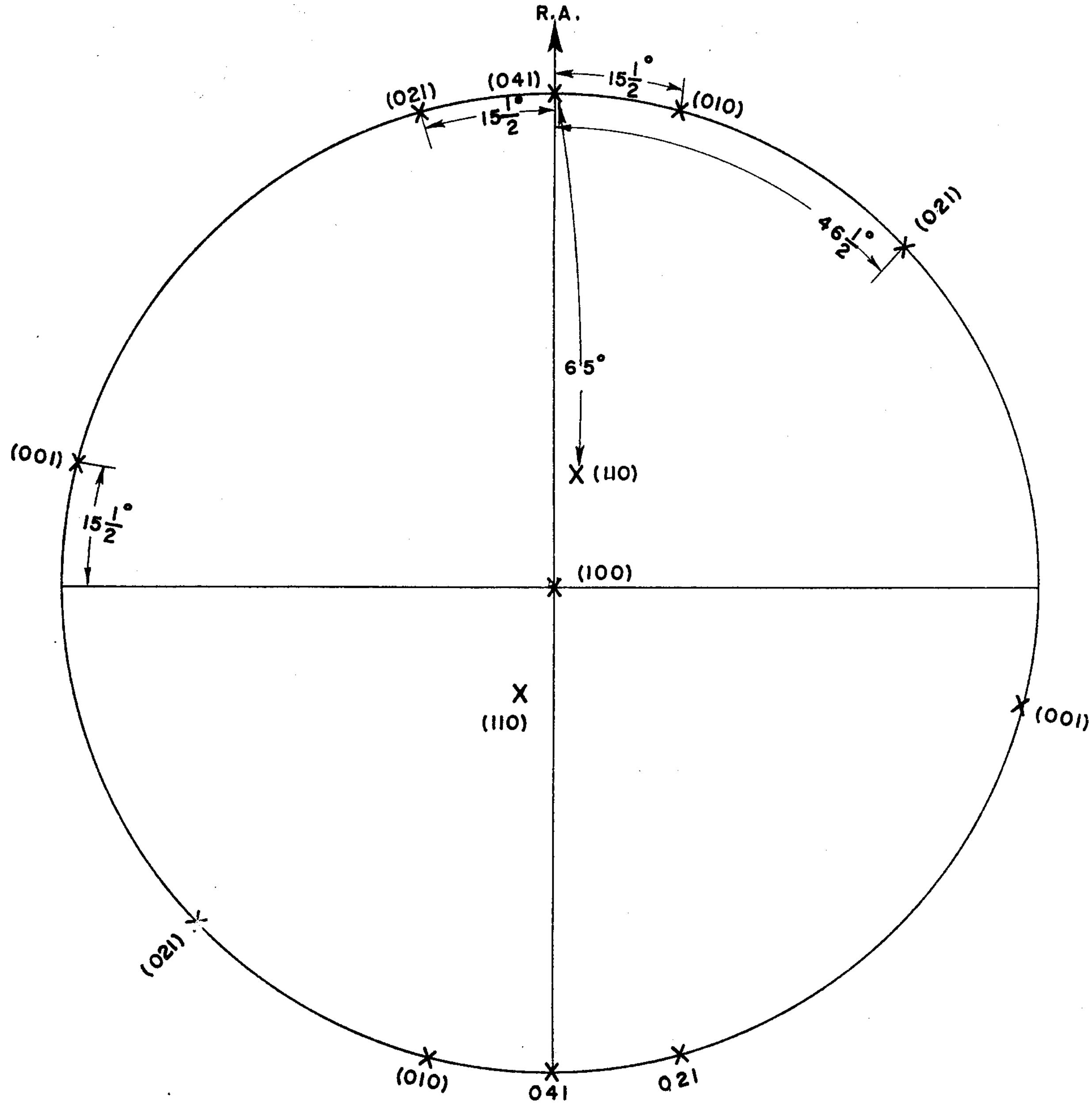


Fig. 11 Mean Orientation of Hot Pressed Rod After 70% R. A. at 300°C.

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