and the obtained $V_k \approx 100$ *kv* and $V_k \approx 1$*kv*, i.e, $V_k > V_a$. However, in Ref.3, we measured I_a when i passed through zero and remained less than 15 amp. (Ref. 3, Fig. 13) while $V_k \leq 23\ V_k < V_a$. In experiments with $V_a \approx 6v$ condition $V_k < V_a$ is also fulfilled, inasmuch as I_a is here measured with the complete exclusion of current i Ref.4, upper curve, Fig. 3*g*). To a lesser degree this condition is observed in Ref. 6, Sec. 2, where I_a was measured at i = 17 amp, but even in this case

$$V_k < 29\ \text{V} < V_a (62\ \text{V} \leqslant V_a \leqslant 70\ \text{V}).$$

It is obvious that the condition $V_k < V_a$ was maintained during our measurements: besides the anomalous current I_a there is also observed the normal anode current which precedes it and which, according to Ref. 1, cannot take place in the absence of discharge (Ref. 4, Fig. 4, *g,h* and Fig. 6, *a–h*, where $V_k \approx 90\ V < V_a$). The absence of discharge is insured here because in normal emission Langmuirs' law holds and the $I_a = I_a\ (t)$ curve has a plateau (Ref. 4, p. 496).

Thus, the explanation proposed in Ref. 1 of the anomalous anode current as caused by the discharge, and the explanation of the E_c dependence on i by the macroscopic movement of the metal, are contrary to the results of our experiments. The data contained in Ref. 1 and 8 do not furnish a basis for renouncing the conclusions given above (*a–e*).

*During measurements of I_a and I_n the potential difference between the ends of the emitter was maintained below the discharge ignition potential.

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Translated by J. L. Herson
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Investigation of the Allotropic Transformation $\alpha \rightleftarrows \beta$ Zr with the Aid of an Electronic Projector

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(Submitted to JETP editor October 29, 1956)
J. Exptl. Theoret. Phys. (U.S.S.R.) 32, 184 (January, 1957)

THE use of an electronic projector permits a visual observation of phase transformations in metals at crystal particle dimensions of the order of 10^{-4}-10^{-5} cm, with a resolving power of 100-20A. The investigation of transformations in such small crystals has independent interest, since the increased role of surface energy must have an effect at such small dimensions.

The usual Muller[1] electronic projector was used, with a zirconium point, the monocrystalline tip which was the object of investigation. The investigation of zirconium in an electronic projector makes special demands on the quality of the vacuum, since with heating, there is a strong tendency to form oxides, nitrides, and carbides of zirconium which are extremely refractory and nonvolatile, and consequently, are not removed from the surface by heating the point in vacuum.

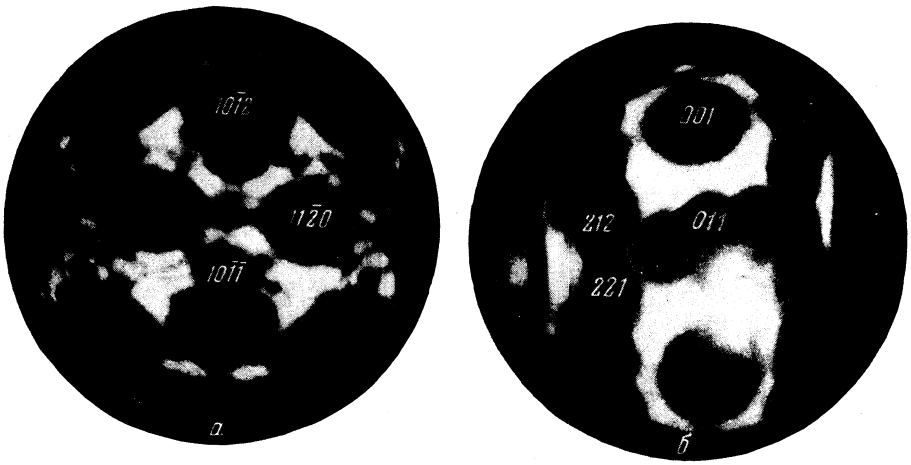
In spite of the fact that the pressure of the residual gases in the bulb of the projector was less than 10^{-8} mm of mercury, it was not possible to obtain a picture of the autoelectronic emission of a smooth crystal similar to the well known picture of a pure tungsten point.

Crystal particles such as α-Zr (hexagonal close packed lattice), as well as β-Zr (cubic volume-centered lattice) were obtained with corrugations. It is natural to associate the corrugation and the clearly expressed faceting of the crystal with the well-known action of an electric field on the crystal during heating[2]. The faceting of the crystal by faces of the cube {001} and {122} is apparently associated with the intrusion into the surface layer of nitrogen atoms from the residual gases. The nitrogen atoms occupy the spaces between metal atoms, which in addition to smoothing the atomic unevenness, increases the durability of the surface layer.

The following steps were taken for the "purification" of the surface: 1) the layer-by-layer

destruction of the surface by heating the point while a high positive potential was applied to it, with a gradient of 1.4×10^8 V/cm at the surface, and 2) condensation on the surface of the zirconium point of a large quantity of zirconium from an external source in a vacuum of the order of 10^{-8} mm of mercury.

By heating the point above the transformation temperature (862°C), it was easy to form a β-Zr crystal, which during cooling was transformed over the entire volume into a unique α-Zr crystal. The process of $\beta \rightarrow \alpha$ transformation was not always geometrically reversible, because with a repeated rise of temperature, a cubic crystal would



Autoelectronic pictures of zirconium monocrystals at the tip of a point: *a* – hexagonal crystal. The axis [0001] is vertical in the plane of the figure. $T = 20°C$. Crystal diameter $d_0 = 1.6\mu$; *b* – cubic crystal. $T = 1060°C$, $d_0 = 3\mu$.

sometimes form with a different orientation than the original. However, in all of the observed cases for the mutual orientation of the crystal the original and new phases satisfied the relations found by Burgers[3] with x-rays

$$\{0001\}_\alpha \parallel \{110\}_\beta \quad \text{and} \quad [11\bar{2}0]_\alpha \parallel [\bar{1}\bar{1}1]_\beta.$$

This allows the possible occurrence of 12 orientations of the new phase for $\beta \rightarrow \alpha$ transitions, and 6 orientations of the new phase for $\alpha \rightarrow \beta$ transitions, corresponding to one orientation of the original phase. But for the observed microcrystals, the experiments showed that as a rule, one (rarely two) of the possible orientations of the new phase was realized. Similar effects were observed by Brock[4] with titanium. It was noted that of the possible orientations, those which lead to the minimum change of surface energy were realized. This is quite natural for crystals of such small dimensions.

A noticeable rise of the transition temperature with an increase of heating duration was observed, associated with absorption by the zirconium of O_2 and N_2 from the residual gases at a pressure lower than 10^{-8} mm of mercury.

A more detailed presentation and discussion of these experiments will be given in the Journal, "Physics of Metals and Metallurgy".

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Translated by D. Lieberman
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