1. In [1] the conclusion is arrived at that the degree of manifestation of plastic self-indentation, which is quantitatively characterized by the dimensionless ratio of the contact circle radius \( X \) to the radius \( R \) of spheres in contact, i.e., \( (X/R)^* \), must increase with decreasing \( R \). This predicted size effect would be expected to be a consequence of the fact that, regardless of the radius of a prismatic dislocation loop, the contribution from the latter to bringing the centers of the spheres closer to the contact plane is equal to the Burgers vector \( b \), yet the energy of the loop falls logarithmically with decrease in its radius \( X \). The results of a calculation [1] of the anticipated effect for the case of contact between two spheres are shown in Fig. 1 (curve 2).

In this article experimental data are cited, obtained by both the present and other authors, demonstrating that the size effect does manifest itself during self-indentation. Comparison of experimental and calculated \( (X/R)^* = f(R) \) curves may prove to be a source of new information on laws governing the plastic formation of a contact.

2. Before considering experimental data, however, let us remind ourselves that contact formation by a plasticity mechanism in high-temperature self-indentation may be represented as taking place in two stages (see [1]). The first stage consists in the formation of a dislocation pile-up under the contact, and the second, in thermally activated resorption of this pile-up. In the first stage a contact is formed whose size is determined by the quantity \( (X/R)^* \), while in the second stage the contact grows in size until \( (X/R)^* \) reaches its limiting value, \( (X/R)^\dagger \), at which the capillary force on the given contact site is no longer capable of maintaining a stress sufficient for the operation of dislocation sources.

As mentioned above, the \( (X/R)^\dagger = f_\dagger(R) \) relationship has already been calculated (see Fig. 1, curve 2). Let us now estimate the quantity \( (X/R)^\dagger = f_1(R) \).

The generation in the contact zone of \( N \) prismatic dislocation loops forming a pile-up under the contact reduces the distance from the sphere centers to the contact plane by

\[
r = Nb.
\]

The value of \( N \) is given by the expression [1]

\[
N = \frac{3^{4/3}(1 - \nu)F_c^{4/3}}{(2\pi)^{1/3}2^{5/3}X^{5/3}\tau_t^{1/6}Gb\ln N},
\]

where \( F_c = 2\pi RA_\alpha; \Delta a = 2a_\alpha - a_\beta; a_\alpha \) and \( a_\beta \), the surface and boundary energies, respectively; \( \tau_t \), the threshold stress with respect to dislocation slip; \( G \), the elastic modulus; and \( \nu \), Poisson's ratio. Now \( h = X^2/2R \), and consequently, after self-evident transformations, we obtain the following estimate of the function \( (X/R)^\dagger = f_1(R) \) of interest to us:

\[
(X/R)^\dagger = AR^{4/11},
\]

where

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Fig. 1. Variation of degree of self-indentation with radius of spheres in contact: 1) extent of effect in stage of formation of dislocation pile-up; 2) full extent of effect; 3) experimental results for silver balls heated up to $T = 670^\circ C$, obtained by us (a) or reported in [2] (b), [3] (c), and [4] (d); 4) results of our experiments with silver balls heated up to $T = 900^\circ C$.

Fig. 2. Variation of $\log(X/R)$ with $\log R$ (2). The dotted lines are theoretical plots for slopes of $4/11$ (3) and $4/7$ (1).

$$A = \left[ \frac{3^{\frac{2}{11}} \pi (\Delta \alpha)^{\frac{4}{11}} (1-\nu)}{2^{\frac{4}{11}} \tau T G \ln N} \right]^{\frac{1}{11}}.$$  

The $(X/R)_1^{*} = f_1(R)$ relationship obtained is shown graphically, at the values of the constants $G = 2 \cdot 10^{11}$ dyn/cm$^2$, $\nu = 0.3$, $\Delta \alpha = 2 \cdot 10^3$ dyn/cm, $\tau T = 10^5$ dyn/cm$^2$, and $\ln N = 5^*$, in Fig. 1 (curve 1). The position of curve 2 in Fig. 1 above curve 1 may be due to the fact that the thermally activated resorption of a dislocation pile-up makes an appreciable contribution to the formation of a contact during self-indentation.

3. Let us now examine experimental data. The relevant relationship, $(X/R)_s^{*} = f_3(R)$, is represented in Fig. 1 by curve 3. All the experimental results apply to silver, and were either taken from [2-4] or obtained by us. They cover a range of variation of $R$ of three orders.

Comparison of the calculated and experimental curves demonstrates that a size effect is in fact observed during self-indentation. It also reveals that, under conditions such as those obtained in the experiments under consideration, the full reserve of plasticity in self-indentation is not used up in the process of resorption of dislocation pile-ups. This may be ascribed to the presence of various obstacles to dislocation motion. When the intensity of thermal fluctuations is increased by changing the temperature, the contribution from the resorption of dislocation pile-ups to the contact formation process grows (see Fig. 1).

It must be pointed out that in the plotting of curve 3 use was made of experimentally found values of $(X/R)^{*}$ referring only to an initial stage of sinter-bonding, whose duration did not exceed a few minutes.

Such a length of time could be sufficient for some diffusion mechanism, in particular the surface diffusion mechanism, to make an appreciable contribution to contact formation. This surmise is not without foundation, especially when one bears in mind that assessments of the coefficient of surface self-diffusion made with the expression [5]

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*The quantity $\ln N$ was calculated from the expression $\ln N = \ln (X/R)^2 R/b$ (see [1]), the value of $(X/R)$ being taken from experiment. It should be noted that the quantity $\ln N$ depends only very slightly on $R$ in the range of variation of $R$ investigated.