Theoretical strength of ideal crystals in plastic shear had already been determined in the 1930s by J. Frenkel. It was established that the stress $\tau_s$ at which plastic shear starts is proportional to the shear modulus $\mu$ and the ratio $\mu/\tau_s \approx 5$. Subsequent determinations showed that $30 \geq \mu/\tau_s \geq 5$. Experimental data for filament crystals has made it possible to assume that the minimum value of this ratio is $\mu/\tau_s \approx 15 [1]$.

Below it will be shown that the ratio of Young's modulus to the normal failure stress from rupture is a value of the same order.

With the use of the dielectric formalism, let us calculate the inverse component of the normal stress $\sigma_0$ applied in some plane cross section at which an isotropic metal ruptures in this cross section. At the same time, the possible rearrangement of the lattice in the surface layers in separation of the metallic portions is not taken into consideration. The ionic framework is replaced by a uniform "gel," the charge of which is compensated by the charge of the electrons. The system of valence electrons is confluent and the calculations are made with $T = 0^\circ$K.

Let us use the simplest formula for the dielectric permeability of metals $\varepsilon(\omega, k)$, which is dependent upon the frequency $\omega$ and the wave number $k$ and asymptotically describes the zeros and the poles of this function [2]:

$$
\varepsilon(\omega, k) = 1 + \frac{\omega_0^2}{\alpha(\omega) \frac{v^2}{\omega_0^2} - \omega^2};
$$

$$
\alpha(\omega) = \frac{4}{9} + \frac{7}{45} \left(\frac{\omega}{\omega_p}\right)^2;
$$

$$
\varepsilon(\omega_p, k) = 0; \quad \omega_0^2 = \frac{4\pi e^2 n}{m},
$$

where $\omega_0$, $v$, and $n$ are the plasma frequency, the Fermi velocity, and the concentration of electrons of the valence zone (the zone of conductivity), respectively, and $e$ and $m$ are the charge and mass of the electron.

The concrete numerical coefficients in the equation for $\alpha(\omega)$ provide with an accuracy to small quadratic terms with respect to $v^2k^2/\omega_0^2$ the dispersion of the volume plasmons:

$$
\omega_p^2 = \omega_0^2 + \frac{3}{5} v^2 k^2
$$

and the accurate long-wave limit for the correlation energy of the electrons with the use of the pole of the dielectric permeability [3]:

$$
\omega^2 = \frac{4}{9} v^2 k^2.
$$

Let us consider a system consisting of two semiinfinite portions of metal separated by the gap $l$. Then in the approach of the random phases (loop approach) the nonadditive component of the energy of interaction of the system is written in the form [4-6] (in calculation for a unit of area of the surface)

$$
\Delta E(l) = -\frac{h g}{4} \int \frac{d^2k}{(2\pi)^2} \frac{1}{2\pi i} \int_{-\infty}^{\infty} \omega \frac{\partial}{\partial\omega} \ln D(\omega, k, l) d\omega,
$$

where

$$
D(\omega, k, l) = 1 - \frac{(\varepsilon(\omega, k) - 1)}{\varepsilon(\omega, k) + 1} \exp(-2kl)
$$

is the left portion of the dispersion equation for the surface waves $D = 0$; $g$ is the multiplicity of degeneration, and $g = 2$. Here in accordance with [5] the spatial dispersion in $\varepsilon(\omega, k)$ for the degenerate electron plasma is taken into consideration.
TABLE 1. Results of Calculation of the Stresses and Ratios of the Elastic Moduli to These Stresses

<table>
<thead>
<tr>
<th>Metal</th>
<th>(\hbar c_{\text{M}}) eV</th>
<th>(b_{\text{G}j}) kgf</th>
<th>(E_{\text{x}})</th>
<th>(\nu_{\text{x}})</th>
<th>(C_{\text{Mx}}) (10^{11}) Pa</th>
<th>(C_{\text{Mx}}) (10^{11}) Pa</th>
<th>(T_{\text{t}}) K</th>
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</thead>
<tbody>
<tr>
<td>K</td>
<td>4.3</td>
<td>120</td>
<td>3.1</td>
<td>2.3</td>
<td>3.0</td>
<td>4.3</td>
<td>83</td>
</tr>
<tr>
<td>Li</td>
<td>8.0</td>
<td>510</td>
<td>2.5</td>
<td>1.9</td>
<td>2.5</td>
<td>4.3</td>
<td>78</td>
</tr>
<tr>
<td>Na</td>
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<td>270</td>
<td>2.2</td>
<td>1.6</td>
<td>2.4</td>
<td>5.2</td>
<td>295</td>
</tr>
<tr>
<td>Ag</td>
<td>12.7</td>
<td>1300</td>
<td>7.2</td>
<td>5.3</td>
<td>7.7</td>
<td>8.0</td>
<td>0</td>
</tr>
<tr>
<td>Al</td>
<td>15.8</td>
<td>2120</td>
<td>3.8</td>
<td>2.8</td>
<td>3.5</td>
<td>2.9</td>
<td>0</td>
</tr>
<tr>
<td>Cu</td>
<td>15.3</td>
<td>2040</td>
<td>6.9</td>
<td>5.2</td>
<td>6.2</td>
<td>8.2</td>
<td>0</td>
</tr>
<tr>
<td>Nb</td>
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<td>3350</td>
<td>3.7</td>
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<td>4.1</td>
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<td>293</td>
</tr>
<tr>
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<td>3370</td>
<td>5.6</td>
<td>4.2</td>
<td>4.8</td>
<td>5.0</td>
<td>293</td>
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<tr>
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<td>2510</td>
<td>5.3</td>
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<td>293</td>
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<tr>
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<td>8.1</td>
<td>6.3</td>
<td>4.2</td>
<td>6.3</td>
<td>290</td>
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<tr>
<td>Th</td>
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<tr>
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<td>3.0</td>
<td>5.3</td>
<td>4.3</td>
<td>0</td>
</tr>
</tbody>
</table>

Using the theorem of the principle of the argument [7], we find:

\[
\Delta E(l) = -\frac{e^2}{4\pi} \sum_{j} \int_{k_s} \left( \omega_{kj}(\infty, k) - \omega_{kj}(l, k) \right) \frac{dk}{2\pi k^2},
\]

where \(\omega_{kj}(l, k)\) and \(\omega_{kj}(\infty, k)\) are the surface plasma frequencies of oscillations of the j-th mode with gaps of \(l\) and \(l \to \infty\), which are the zeros and poles of the function \(D(\omega, k, l)\); and \(k_s\) is the minimum wave vector at which the surface plasmons decompose [8].

The integration is done with respect to the surface \([k_s]\) formed by the set of these vectors. We calculate the values of \(k_s\) from the laws of conservation for the final conditions when \(l \to \infty\) and the plasma modes are split:

\[
\begin{align*}
\omega_{kj}(\infty, k_s) &= v_{||} k_s + \frac{h\omega_{kj}}{2m}; \\
k_s &= \min\{k_s\},
\end{align*}
\]

where \(v_{||}\) is the vector of the Fermi velocity in the plane of the cross section of the Fermi surface. This plane is parallel to the surface of the body and is drawn so that the greatest values of \(v_{||}\) correspond to it.

The forces which must be applied to a unit of area of the surface in order to counterbalance the attraction of the two seminfinite portions of the metals are equal to

\[
f(l) = \frac{d\Delta E(l)}{dl}.
\]

With \(k_0l >> 1\), when the electron systems of the two metals are divided and the spatial dispersion is insignificant, Eqs. (3)-(5) describe the Van der Waals interaction of the bodies [6].

The most normal stress which it is necessary to create for rupture is

\[
\sigma_0 = \lim_{l \to 0} f(l).
\]

The calculation relationships for simple metals with a spherical Fermi surface and with a uniform isotropic surface of separation have the form

\[
\begin{align*}
\sigma_0 &= \frac{h\omega_{0}^4}{32\pi \sqrt{2} \alpha^5} \left( \frac{3\alpha^3}{2\beta^2} - \frac{1}{3} \right); \\
y &= \begin{cases} 
1 - \sqrt{1 - 4 \left( \frac{180 - \alpha}{180} \right)} & \alpha \leq 47 \frac{180}{180}; \\
2 \left( \frac{180}{180} - \alpha \right) & \alpha > 47 \frac{180}{180};
\end{cases}
\end{align*}
\]

...