

FIG. 2. Experimental values of the derivatives  $d \ln \chi / d \ln V$  and plots of Eq. (5) for different values of the parameter  $\beta$ : 1- $\beta = 0$ , 2- $\beta = 0.30 \text{ atom}^{-1}$

polation of the values for the pure components from<sup>[41]</sup>.

In non-annealed alloys containing more than 5 at.% rhodium, the absolute values of the susceptibility are somewhat higher than in annealed ones, but the value of  $d \ln \chi / d \ln V$  remains practically the same.

## DISCUSSION OF RESULTS

A feature of the system of alloys of palladium is the increase of their spin susceptibility  $\chi_s$  by the exchange interaction<sup>[5]</sup>. While facilitating the experiment, this circumstance makes the interpretation more complicated, in view of the appearance of additional parameters. Taking into account the exchange interaction<sup>[5]</sup> we have

$$\chi = \chi_s / (1 - \alpha \chi_s). \quad (2)$$

Recognizing that

$$d \ln \chi_s / d \ln V = \gamma + \beta d \ln \chi_s / d q, \quad (3)$$

we can obtain from (2) and (3)

$$\frac{d \ln \chi}{d \ln V} = [\gamma + \alpha \chi (\gamma + \beta d \ln \alpha / d \ln V)] + \beta d \ln \chi / d q. \quad (4)$$

Expression (4) contains four parameters ( $\alpha$ ,  $\beta$ ,  $\gamma$ ,  $d \ln \alpha / d \ln V$ ), which we assume to be constant for the entire series of the investigated alloys. Using (4) at the point of the maximum  $\chi(q)$  (at 5 at.% rhodium), we can easily replace two of them, pertaining to the exchange interaction, by the experimental values  $\chi_{\max}$  ( $635 \times 10^{-6} \text{ mole}^{-1}$ ) and  $d \ln \chi_{\max} / d \ln V$  (4.66):

$$\frac{d \ln \chi}{d \ln V} = \gamma + \frac{\chi}{\chi_{\max}} \left( \frac{d \ln \chi_{\max}}{d \ln V} - \gamma \right) + \beta \frac{d \ln \chi}{d q}. \quad (5)$$

The determination of the remaining parameters reduces to their choice in (5) until a best description of the data of Fig. 2 is obtained. It turned out that the curve specified by expression (5) is stable against changes in the deformation parameter  $\gamma$ , and to refine it with the aid of (1) we used the experimental values of the Gruneisen parameter  $\gamma_e = 2.1$ <sup>[6]</sup>, and the value  $\partial \ln N / \partial q = -4$  for palladium, which was determined from the low-temperature susceptibility<sup>[3]</sup>.

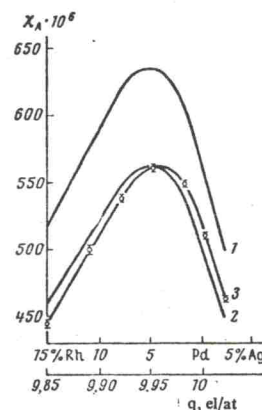
The final values of the parameters are:

$$\gamma = 3.3 \pm 0.3, \\ \beta = 0.30 \pm 0.02 \text{ atom}^{-1}.$$

Figure 2 shows curves described by Eq. (5), illustrating the last stage of the selection of  $\beta$  and the degree of attained agreement with experiment.

Let us consider the main conclusions of the investigation.

FIG. 3. Plots of  $\chi(q)$  at zero pressure (1) and at a pressure corresponding to  $\Delta V/V = -0.025$  ( $5 \times 10^4 \text{ atm}$ ): 2—calculation from Eq. (5) without allowance for the band shift, 3—extrapolation of experimental data.



1. It turns out that the model proposed in<sup>[2]</sup> for the variation of the spectrum under pressure describes successfully the experiment with the aid of parameters that are constant in a considerable interval of the electron concentrations (at least in the region of the maximum of the density of states curve).

2. An important result is also the distinct separation of the effect of the band shift. The corresponding shift of the state-density curve is clearly demonstrated in Fig. 3 by the difference between the positions of the  $\chi(q)$  curves for  $\Delta V/V = -0.025$  ( $P \sim 5 \times 10^4 \text{ atm}$ ), namely, curve 2 was calculated from Eq. (5) without allowance for the band shifts, and curve 3 is extrapolation of the experimental data (curve 1— $\chi(q)$  at  $P = 0$ ). The energy shift of the states of the s and d bands on the Fermi level amounts to (putting  $N_s = 0.14 \text{ eV/atom}$ , as in silver<sup>[7]</sup>)

$$\partial E_{s-d} / \partial \ln V = 1.05 \pm 0.15 \text{ eV},$$

i.e., it is close to the analogous characteristic in chromium alloys<sup>[2]</sup> ( $1.6 \pm 0.5$ ) and has the same sign: under pressure, the s-states drop relative to the d-states.

The manifestation of the band-shift effect should become sharper with decreasing temperature, owing to the increase of  $\partial \ln \chi / \partial q$ . Substitution in (4) of the corresponding low-temperature value of the derivative<sup>[3]</sup> shows that at liquid-helium temperature the effect of the band shift for palladium is predominant, as a result of which the derivative  $d \ln \chi / d \ln V$  reverses sign ( $-3.7$ ). The agreement between the calculated value and the one measured by magnetostriction<sup>[8]</sup> ( $d \ln \chi / d \ln V = -3.5$ ) confirms both the existence of the band shift and the value found for it<sup>1)</sup>.

3. The correctness of the obtained parameter  $\gamma$  is confirmed by the following facts: using Eq. (4) at the point of maximum susceptibility and putting  $\alpha = 0.78 \times 10^4 \text{ mole}$  from<sup>[10]</sup>, we obtain the value  $\partial \ln \alpha / \partial \ln V = -3.0 \pm 0.5$ , which depends on the choice of the parameter  $\gamma$ . It agrees with the results obtained in<sup>[8]</sup>, if one uses the experimental value of the Gruneisen parameter ( $2.1$ <sup>[6]</sup> in lieu of 1.5), namely,  $\partial \ln \alpha / \partial \ln V = -2.7$ .

<sup>1)</sup> After completing the work on this article, the authors became acquainted with the results of investigations of the de Haas-van Alphen effect in palladium under conditions of hydrostatic pressure<sup>[9]</sup>. The character of the change of the extremal section of the Fermi surface, corresponding to s electrons, is in qualitative agreement with the band-shift effect observed by us.