is assumed to be independent of n.

The function $f'(\alpha/\alpha_{cr})(\alpha/\alpha_{cr})$ is shown in Fig. 2, where the constant C has been evaluated for the sample of lowest concentration. Experimental values of α/α_{cr} are determined uniquely from Eq. (2). The data are in good quantitative agreement with this relationship at low concentrations, and in qualitative agreement for the highest concentration point for which only the lower limit of $-(\partial t/\partial P)_{P=0}$ could be determined in our He^4 cryostat.

The discussion given here does not include the complications of the Kondo effect which may be expected in this system because of the large antiferromagnetic s-f exchange interaction; the magnetic-nonmagnetic transition which we infer from the minimum in the curves of T_c vs P may arise from the development of the quasi bound state at higher temperatures with increasing pressure due to a continued increase of $|J_{\text{eff}}|$ with pressure.[10] Alternatively, the minimum in T_c vs P may reflect a gradual onset of magnetic order with increasing pressure. This would also lead to a decrease in pair breaking, and in turn, to an enhancement of T_c.[11] An extension of the $T_c(P)$ measurements to higher pressures, and low-temperature normal-state resistivity measurements at normal and high pressures, will be carried out to examine these possibilities.

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SURFACE NUCLEATION AND BOUNDARY CONDITIONS IN SUPERCONDUCTORS

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We have calculated the surface nucleation field as a function of the slope of the superconducting order parameter at the surface of a semi-infinite superconducting half-space. When the order parameter increases on approaching the surface, as would be the case in the presence of a surface region of enhanced transition temperature, nucleation fields larger than those expected for a uniform sample are predicted. Cold working the surface on an InBi foil produces this condition and qualitatively confirms the prediction.

It has been shown that for an ideal superconducting surface adjacent to a vacuum interface in a parallel applied magnetic field, superconductivity persists in the surface region to a field[1]

$$H_{c3} = 2.38\kappa H_c, \tag{1}$$

where H_c is the thermodynamic critical field and κ is the Ginzburg-Landau parameter. For a type-II material the bulk critical field $H_{c2} = \sqrt{2}\kappa H_c$, and $H_{c3} = 1.695 H_{c2}$. Equation (1) is well verified by a number of investigations.[2]

In numerous cases, however, remnant superconductivity has been found to persist to nucleation fields H_0 which are considerably greater than H_{c3}.[3-5] It has been shown for both type-I[4] and type-II[5] alloys that such enhancements can derive from cold working the sample surface.

In this note we consider the results of changing the boundary conditions on the surface from the usual situation of a vacuum interface. We find that if these changes result in an order parameter which increases in magnitude on approaching the surface, H_0 should in fact exceed H_{c3}. Such a situation could exist if the sample had a surface layer of slightly higher transition temperature than the underlying metal. This circumstance has been realized experimentally in a foil where sizable increases in H_0 have been found simultaneously with small shifts in T_c produced by cold working the sample surface.

We consider a semi-infinite half-space of a superconducting metal located at $x \geq 0$. We assume that the applied magnetic field is parallel to the z direction and of sufficient magnitude such that only superconductivity near the surface of the half-space exists. This means that the order parameter $\Psi(x)$ is finite near the surface and zero in the bulk. Near the nucleation field a second-order phase transition occurs, and one may therefore use the linearized Ginzburg-Landau[6] (GL) equations. The first linearized GL equation is[7]

$$-d^2\Psi/d\zeta^2 + (\zeta - \Gamma)^2\Psi = \mu^2\Psi \quad (\zeta \geq 0). \tag{2}$$

We have assumed for simplicity that $\Psi = \Psi(\zeta)$ is a real function. We have used the following definitions: $\zeta = x/\mu\xi$; $\xi = \xi(T)$ is the temperature-dependent coherence length; the eigenvalue of Eq. (2) $\mu^2 = H_{c2}/H_0$; the vector potential $A = H_0(x + x_0)$; the nucleation center $\Gamma = -x_0/\mu\xi$; H_0 is the applied as well as the nucleation field. Because we have assumed that Ψ is real, the proper choice of the gauge (x_0 or Γ) determines the lowest energy state. This is done by finding the first integral of the first and second GL equations between the limits $x = 0$ and $x = \infty$. We assume that $\Psi(0)$ is arbitrary (e.g., unity) as Eq. (2) is linear; $\Psi(\infty) = 0$; $(d\Psi/d\zeta)_\infty = 0$. We assume that the superconducting half-space is in contact with some material at $\zeta = 0$ which affects the slope of Ψ at $\zeta = 0$. The extrapolation length[8] b is defined by $(d\Psi/dx)_0 = \Psi(0)/b$. It follows from the second GL equation that this boundary condition implies that the mean current crossing the boundary is zero for an arbitrary value of b. However, the canonical momentum perpendicular to the boundary is continuous for $b \neq \infty$. When $b = \infty$, the value of $(d\Psi/dx)_0 = 0$, and one obtains from the lowest eigenvalue of Eq. (2) the usual surface nucleation field[1] $H_{c3} = 1.695 H_{c2}$.

If b is arbitrary, the first integral of the GL equations with the above-stated boundary conditions leads to the minimum energy condition

$$\mu^2[1 + (\xi/b)^2] = \Gamma^2. \tag{3}$$

Equation (2) was solved together with Eq. (3), and the eigenvalues $\mu^2 = H_{c2}/H_0$ were determined for various values of ξ/b. The nucleation field H_0 is plotted in Fig. 1 as a function of ξ/b. When $b \geq 0$ ($d\Psi/d\zeta \geq 0$), the value of H_0 is between H_{c2} and H_{c3}, and when $b < 0$ ($d\Psi/d\zeta < 0$ in our coordinate system), the value of $H_0 > H_{c3}$.

One could imagine that $b < 0$ could actually exist if the material located on the left of the origin ($\zeta < 0$), which is in contact with the superconductor at $\zeta = 0$, would, for example, be a superconductor with a larger transition temperature than that under consideration on the right of the origin ($\zeta \geq 0$). This would be a mechanism which would enhance the value of the nucleation field of the material on the right to values larger than that given by (1). Hence if superconducting inclusions exist near the surface of a superconductor whose effective transition temperature is larger than that of the matrix, the surface-nucleation field of the matrix could be enhanced. Although b is not a directly measurable quantity, experiments

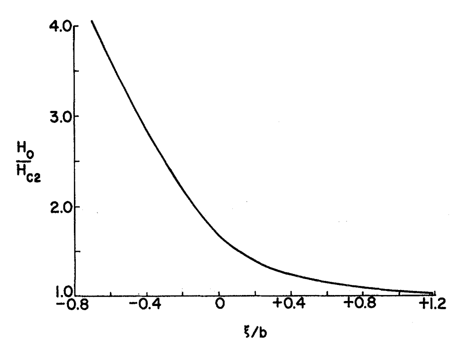

FIG. 1. The surface nucleation field H_0, normalized with respect to the bulk nucleation field H_{c2}, is plotted as a function of ξ/b, where ξ is the temperature-dependent coherence length and b is the extrapolation length. The latter is a measure of the slope of the order parameter at $x = 0$.

seem to indicate that negative values of b could explain qualitatively the experimental data.

We have experimentally examined the case of foil of $In_{0.993}Bi_{0.007}$. The foil was compressed from an alloy ingot between glass microscope slides and subsequently annealed under vacuum for 3 days at 130°C. The sample was mounted in a standard, four-probe sample rig, and its transition temperature measured resistively using small measuring currents and with the earth's magnetic field compensated to less than 1/20 Oe. A current of 10^{-2} A produced a voltage of 1 μV in the fully normal state. This transition is shown in Fig. 2. The transition takes place over about 32 mdeg. This finite width of the transition cannot be accounted for by the imperfect cancellation of the earth's magnetic field and the self-field of the measuring current since the transition becomes somewhat sharper, chiefly through suppression of the high-temperature tail, when measuring currents one to two orders of magnitude larger are used. Small regions with slightly higher transition temperatures than the bulk must therefore be present in the sample.

Critical-current data were obtained at lower temperatures using procedures described in detail elsewhere.[4] The critical current was defined as that current required to produce 1 μV across the sample. Results of this measurement are shown in Fig. 3 where the data are presented in terms of critical supercurrents, the current required to produce 1 μV in the normal state having been subtracted out.[9] Because of noise limitations on the extent to which we could follow the transition to small currents, we arbitrarily define H_0 as the nucleation field at a critical supercurrent of 5×10^{-4} A. We estimate $\kappa = 0.37$ for this sample[10] and hence expect a sharp transition at H_c (indicated by the arrow in Fig. 3), since $H_{c3} < H_c$. The observed extension of the transition to a field H_0 about 70% higher than the expected transition field is typical of nonideal samples, and we associate this with the regions of higher transition temperature which contribute to the finite transition width in zero field.

The sample surface was then severely cold worked by repeated stroking with fine crocus, a procedure which has been shown to produce large nucleation-field enhancements in other alloy systems.[4] The transition temperature and critical currents were again determined with results as shown in Figs. 2 and 3. The transition temperature of the worked surface was increased, the high-temperature tail of the transition showing transition-temperature enhancements of over 40 mdeg, and the low-temperature tail, about 16 mdeg. The transition curve of the sample with the worked surface became more sensitive to measuring current than with the unworked surface indicating that portions of the worked re-

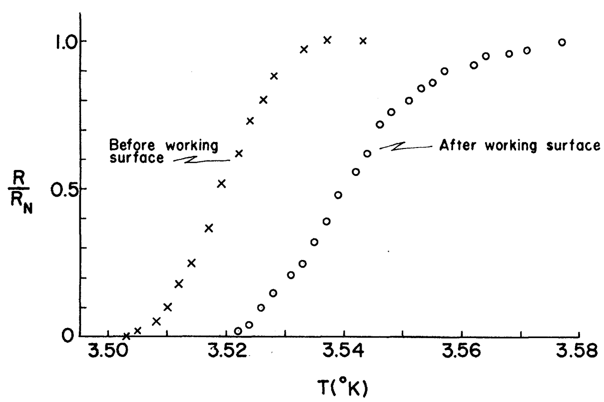

FIG. 2. The normalized resistance R/R_N is plotted versus temperature for an $In_{0.993}Bi_{0.007}$ foil with unworked and worked surfaces. The measuring current used for these transitions was 10^{-2} A. The earth's magnetic field was compensated to less than 1/20 Oe. The observed transitions were sensitive to measuring current, especially with the worked surface. Higher currents narrowed the transition somewhat, principally by quenching the high-temperature tail.

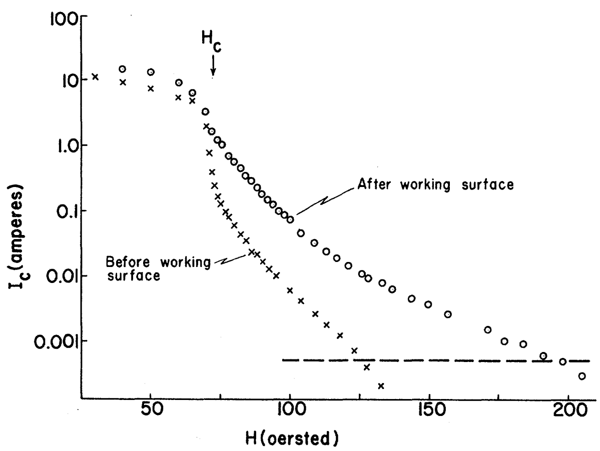

FIG. 3. Critical supercurrents versus field are shown for foil with unworked and worked surface. The broad face of the foil is aligned parallel to the applied field and the current is parallel to the field direction. The critical current is the current required to produce 1 μV along the sample. The currents shown are critical supercurrents, the current required to produce 1 μV in the normal state having been subtracted from the data. The curves shown were obtained at $T = 2.992$°K. H_c is determined to be 72 Oe at this temperature. The dashed horizontal line at 5×10^{-4} A represents the usual noise limitations on our instrumentation and is used to define H_0.

gions with enhanced transition temperature are of sufficiently limited extent that their superconductivity can be quenched by the measuring currents. The critical field and critical currents were dramatically increased by the surface working, H_0 being increased 60 % beyond the value obtained in the unworked surfaces.

We have therefore shown both theoretically and experimentally that under conditions of a negative extrapolation length at a sample surface an enhancement of surface superconductivity to higher critical fields will take place.

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EFFECTS OF THE ELECTRON-MAGNON INELASTIC SCATTERING ON THE POLARIZATION OF PHOTOEMITTED ELECTRONS

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Polarization effects due to inelastic scattering from magnons is shown to alter significantly the original polarization of photoemitted electrons from the conduction bands of Gd.

The polarization of photoelectrons and field-emitted electrons from ferromagnets has been the topic of a number of papers. For a review of the field and references, see the article by Farago.[1] Recently two experiments successfully measured the polarization of field- and photoemitted electrons from a ferromagnet. The first experiment, reported by Hoffmann *et al.*,[2] measured the degree of polarization of field-emitted electrons from polycrystalline gadolinium. The polarization was found to be antiparallel to the direction of the magnetization and had a magnitude of about $(8 \pm 1.5)\%$. The second experiment, reported by Busch *et al.*,[3] measured the degree of polarization of photoelectrons from gadolinium. The polarization was also found to be antiparallel to the magnetization and had a magnitude of $(5.27 \pm 0.70)\%$. Müller, Siegmann, and Obermair,[4] using a parabolic-band model for Gd, predicted theoretically the polarization for field-emitted electrons to be 6% antiparallel to the magnetization, in qualitative agreement with Hoffmann's observation.

It has been suggested that the polarization of these emitted electrons can be correlated directly with the polarization of the electrons in the conduction band.[2-4] These attempts at direct correlation have neglected the polarization effects of inelastic magnetic scattering and of spin-dependent transmission at the interface of the crystal. In this paper we show that the polarization effects due to inelastic scattering from magnons can significantly alter the original polarization of photoemitted electrons from the conduction bands of Gd. In what follows we consider specifically the process of photoemission, although it is expected that similar considerations need to be made for field emission. Our aim in this paper is not to reinvestigate in detail the theories of photoemission for the purpose of accurately calculating the polarization of the emitted electrons, but rather to consider what corrections to the present simple theories are likely to be required by a more complete theory.

Photoemission from solids is described by a three-step process. Electrons are first optically