FIG. 6. Variation of the coefficient A_1 with pressure.
o —Run 1; ●—Run 2; △—Run 3.

A_1 is rather insensitive to pressure. Unfortunately, despite the apparently small magnitude of (dA_1/dP) and its consequent experimental uncertainty, the (dA_1/dP) term in (7) makes a contribution of the same order of magnitude as the more accurately known (dH_0/dP) term. Accordingly, the possible error in (dA_1/dP) introduces a substantial uncertainty into the calculation of $(1/\gamma^*)(d\gamma^*/dP)$.

It seems possible that more measurements at lower temperatures will permit a more direct and accurate determination of (dA_1/dP). However, such measurements on Pb will be complicated by uncertainties introduced by the hysteresis correction which becomes more acute as 0°K is approached.

3. The H_c-T-P Surface for Lead

The present measurements permit a determination of the analytical form of the thermodynamic surface which separates the superconducting and normal regions above the P-T plane for the case of Pb. The critical field of Pb may be expressed in terms of reduced coordinates as follows.

$$h(P,t)=H_c(P,t)/H_0(P)=\sum_{n=0}^{5} a_n(t^2)^n, \qquad (9)$$

where $a_0=1$ and $t=(T/T_c)$. We find that the data for all isobars measured in the present work are precisely represented by this expression. The differences between $h(P,t)$ at all temperatures and pressures of measurement and $h(0,t)$ as previously reported by Decker et al.[12] are of the order of 1 or 2×10^{-4} which is about the limit of precision of the present critical field measurements. Thus, to present experimental accuracy, the coefficients, a_n, in (9) are independent of pressure. This property (the invariance of the a_n under pressure) will be designated hereafter as "geometrical similarity" which, as shown later, is one (but not the only) condition of the familiar "similarity principle."

If our results are idealized by the assumption that geometrical similarity is exactly obeyed, the critical field

surface may be described by the following expression

$$H_c(P,T)=H_0(P)f(t), \qquad (10)$$

where $H_0(P)$ is the linear function of P described above and $f(t)$ is the reduced critical field curve of Decker et al.[12] In the following discussion we offer further evidence to support the suitability of this representation for the H_c-T-P surface of Pb.

(a) *Temperature variation of* $(\partial H_c/\partial P)_T$. The consistency of the assumption expressed in (10) with experimental observations may be demonstrated by comparing the results which it predicts with the observed temperature dependence of $(\partial H_c/\partial P)_T$.

Differentiation of (10) yields

$$(\partial H_c/\partial P)_T=f(t)(dH_0/dP)$$
$$-(H_0/T_c)(dT_c/dP)t(df/dt), \quad (11)$$

and (dT_c/dP) may be evaluated from the general relation

$$(\partial T/\partial P)_{H_c}=-(\partial H_c/\partial P)_T(\partial T/\partial H_c)_P.$$

At $T=T_c$ and $P=0$, this becomes

$$dT_c/dP=-\frac{(\partial H_c/\partial P)_{T=T_c}}{(\partial H_c/\partial T)_{P=0}}. \qquad (12)$$

For comparison with experimental data, it is convenient to cast (11) into a dimensionless form by dividing through by (dH_0/dP). The resulting equation is

$$\Delta H_c(P,t)/\Delta H_0(P)=(\partial H_c/\partial P)_T/(dH_0/dP)$$
$$=f(t)-Bt(df/dt), \quad (13)$$

where

$$B=\frac{H_0(dT_c/dP)}{T_c(dH_0/dP)}=\frac{d\ln T_c/dP}{d\ln H_0/dP},$$

and $\Delta H_c(P,t)$ and $\Delta H_0(P)$ are the shifts resulting from the same applied pressure at the temperature corresponding to t and at 0°K, respectively.

Accurate evaluation of B involves an extrapolation to determine $(\partial H_c/\partial P)_{Tc}$. We shall defer comment on this point until later since the extrapolation depends on the validity of (10) which is presently under consideration. For the moment we simply assert that B is practically independent of pressure.[15] Thus, it follows that (13) describes a relation which is independent of the pressure of measurement. The comparison between experimental values of $\Delta H_c/\Delta H_0$ for various pressures and the predictions of (13) via (10) is shown in Fig. 7. The agreement is quite satisfactory.

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[15] Irrespective of its actual magnitude, the invariance of B with respect to change in pressure follows from the fact that it is determined by the ratio of the derivatives (dT_c/dP) and (dH_0/dP). Within the range of pressure employed here, H_c varies linearly with pressure at all temperatures. Thus, the pressure derivatives in the expression for B [which are computed from the limiting values of $(\partial H_c/\partial P)_T$ at $T=0$ and $T=T_c$] must be independent of pressure and the same must be true of B.