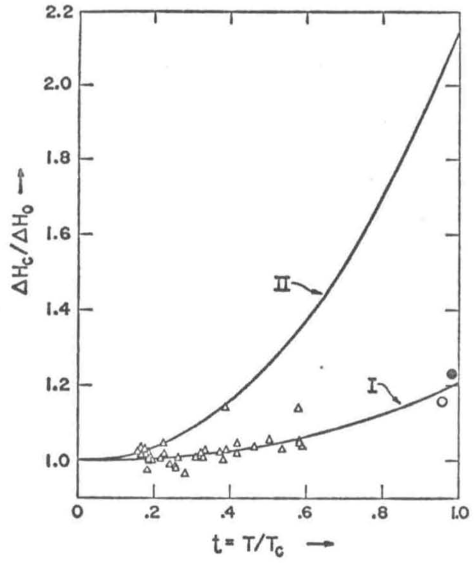

FIG. 7. Normalized variation of pressure shift with temperature. Curve I is obtained using the assumption of geometrical similarity and measured values of dH_0/dP and dT_c/dP. Curve II assumes geometrical similarity and also H_0/T_c=const (i.e., the similarity principle). △'s give results at various pressures up to 9550 psi which, in this representation, should be independent of the pressure. ○ (present work) and ● (reference 6) are results of measurements using gaseous helium near T_c.

It is interesting to compare the results shown in Fig. 7 with the "similarity principle"—a term generally understood to describe the simultaneous validity of the following two conditions: (a) geometrical similarity (as previously defined) and (b) the requirement that $H_0(X)/T_c(X)$ is independent of X, where X is an independent variable such as the pressure or the isotopic mass.[16] Although these two conditions are independent, available evidence as well as theoretical considerations indicate that both apply in the case of the isotope effect (in which connection the term "similarity principle" was first introduced).[17,18] Previous pressure effect results have suggested that the similarity principle was obeyed in the case of tin but not in the case of indium.[16]

The condition of a constant value of H_0/T_c is definitely not fulfilled in the case of Pb. If H_0/T_c were constant, it would follow that

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

which gives the value $B=1$ in Eq. (13). The value, $B=1$, leads to the curve marked II in Fig. 7 which is clearly beyond the limit of the experimental uncertainty, especially near T_c. (Curve I, which fits the experimental data, corresponds to a value of $B=0.562$.) Even though the scatter of the experimental points in Fig. 7 is appreciable, the data seem good enough to provide reasonable confirmation of the hypothesis which underlies curve I.

It will be noted that the slopes of curves I and II differ by a factor of almost 6 at T_c. This is enough to introduce appreciable error into the extrapolation of experimental values of $(\partial H_c/\partial P)_T$ to T_c if such extrapolation were made according to the similarity principle.

(b) *Pressure effects on* T_c. The value of dT_c/dP is of interest for comparison with theory and to permit the calculation of the constant B introduced in (13). As shown in (12), dT_c/dP requires knowledge of the values of $(\partial H_c/\partial P)_T$ and $(\partial H_c/\partial T)_P$, both evaluated at $T=T_c$. An accurate value of $(\partial H_c/\partial T)_P$ is available from earlier work,[12] but determination of $(\partial H_c/\partial P)_{T=T_c}$ involves extrapolation of measurements made at temperatures below T_c and is somewhat sensitive to the analytic form of the H_c-T-P surface.

Assuming the validity of (10) it follows quickly from (11) and (12) that

$$(\partial H_c/\partial P)_{T_c}=(T_c/H_0)(1/t)(dt/df)(\partial H_c/\partial T)_{T_c} \times[(\partial H_c/\partial P)_T-f(t)(dH_0/dP)], \quad (14)$$

where $(\partial H_c/\partial P)$ is the experimental value obtained at the temperature $T=T_ct$.

The value obtained from (14) in the present work is

$$(\partial H_c/\partial P)_{T_c}=-(6.23\pm0.10)\times10^{-4}\text{ gauss/psi}$$
$$=-(9.15\pm0.15)\times10^{-3}\text{ gauss/atm},$$

and, using (12),

$$dT_c/dP=-(3.84\pm0.07)\times10^{-5}\text{ deg/atm}.$$

These values are about 6% smaller than a similarly corrected value derived from earlier measurements near T_c by Hake and Mapother.[19] For reasons not clearly understood, this difference is greater than the reported experimental error, but the discrepancy does not seriously complicate the picture as can be seen from Fig. 7. The two experimental points nearest T_c in Fig. 7 were obtained by calculating $\Delta H_c/\Delta H_0=(\partial H_c/\partial P)_T/(dH_0/dP)$ using experimental values of the derivatives obtained in the present work and from the corrected value of $(\partial H_c/\partial P)_T$ of the previous pressure effect work.[6] The scatter of these points is not substantially worse than that apparent in some of the lower temperature measurements shown in the same figure. Thus, this uncertainty does not compromise the previous conclusions regarding the validity of curve I.

[16] N. L. Muench, Phys. Rev. **99**, 1814 (1955).
[17] J. M. Lock, A. B. Pippard, and D. Shoenberg, Proc. Cambridge Phil. Soc. **47**, 811 (1951).
[18] R. W. Shaw, D. E. Mapother, and D. C. Hopkins, Phys. Rev. **121**, 86 (1961).

[19] Corrections must be applied to the earlier reported value in the light of recently improved accuracy in the knowledge of the superconducting constants of Pb. These corrections affect the earlier values of the temperature of measurement, T_c, $(\partial H_c/\partial T)_P$, and also the earlier assumption that the similarity principle was valid. The final corrected value is $(\partial H_c/\partial P)_T=-(6.63\pm0.12)\times10^{-4}$ gauss/psi $=-(9.75\pm0.18)\times10^{-3}$ gauss/atm and $dT_c/dP=-(4.09\pm0.08)\times10^{-5}$ deg/atm.