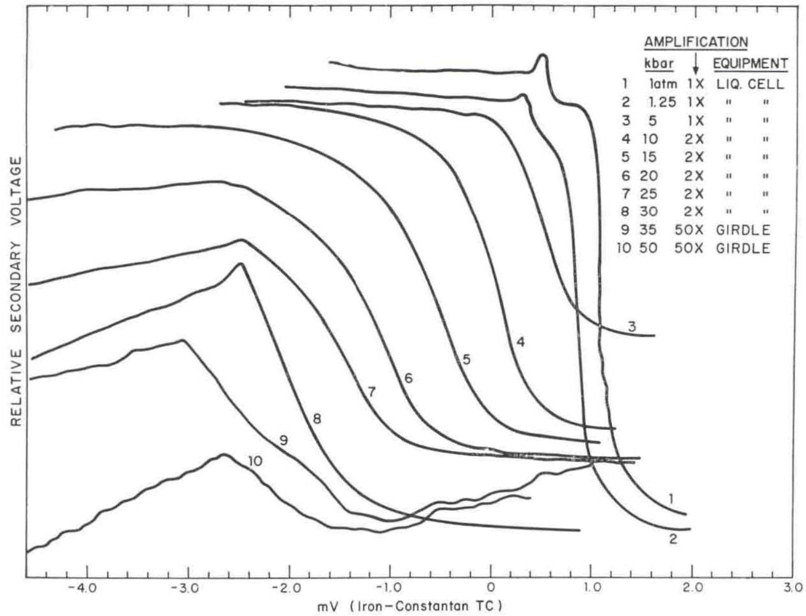

FIG. 3. Relative secondary voltage vs thermocouple output in mV for MnP powder dispersed in epoxy cement. There was 50–75 wt% MnP in the cast samples. The washer-shaped specimens were bifilar wound over ~85% of their circumference. Curves #9 and #10 emphasize the greater amplification required for the samples in the girdle pressure cell and the resulting increase in noise. (Curves for Figs. 3–7 were traced directly from the *X–Y* plots made during the cooling portion of the cool–heat cycles.)

In Fig. 2 are plotted the temperatures of the peaks of the secondary voltage vs temperature curves for the high-pressure ($P \geqslant 25$ kbar) runs. These peaks appear about 10° higher in the hydrostatic equipment than in the girdle-die unit, which gives an apparent decrease between 30 and 35 kbar in the temperature for the peak. However, if the data for just the girdle-die is considered (Table I), there is little change for this peak between 30 and 40 kbar, but there is a definite increase in temperature for this peak at 50 kbar. This suggests that between 25 and 35 kbar the magnetic phase below the magnetic-ordering temperature changes from ferromagnetic to antiferromagnetic. If the transitional phase is metamagnetic, as predicted by Goodenough (*6*), then the transitional pressure would be poorly defined. Although the system is hydrostatic at 30 kbar and room temperature, at 220°K it is probable that the iso-amyl alcohol–pentane mixture is also a solid. This might contribute to a smearing of the transitional pressure. Nevertheless, at 25 kbar the single-crystal torroids were not damaged after cooling to 160°K, so there were no appreciable stress inhomogeneities under these conditions.

At 1 atm the curves for the secondary voltage vs thermocouple output for several powder-epoxy samples exhibited an anomalous peak—see Fig. 3 for a typical example—which is not characteristic of a simple ferromagnetic ordering. Since MnP has an exceptionally large magnetic anisotropy, this anomaly was studied in two single-crystal specimens, cut in the form of washers, and in one single-crystal "picture frame" oriented with respect to the crystal axes. Both a powder-epoxy ring with carefully positioned winding and rings from polycrystalline ingots were also studied at ~1 atm. The influence of winding position on single-crystal and polycrystal ring samples was carefully investigated to demonstrate the sensitivity of the shape of the permeability curves to the position of the windings relative to the crystallographic axes.

Washers cut from the first single-crystal ingot, #10-736, whose axis had no close relationship to any crystallographic direction, gave the curves shown in Fig. 4. These curves have very sharp peaks and sharp changes in secondary voltage, so that the peak temperature is essentially the same as the temperature for the midpoint of the voltage change. The valley in the curve below the peak gradually flattens out with pressure, so that at 25 kbar it is nearly gone and the shape is approximately that for a typical ferromagnetic transition. This is in contrast

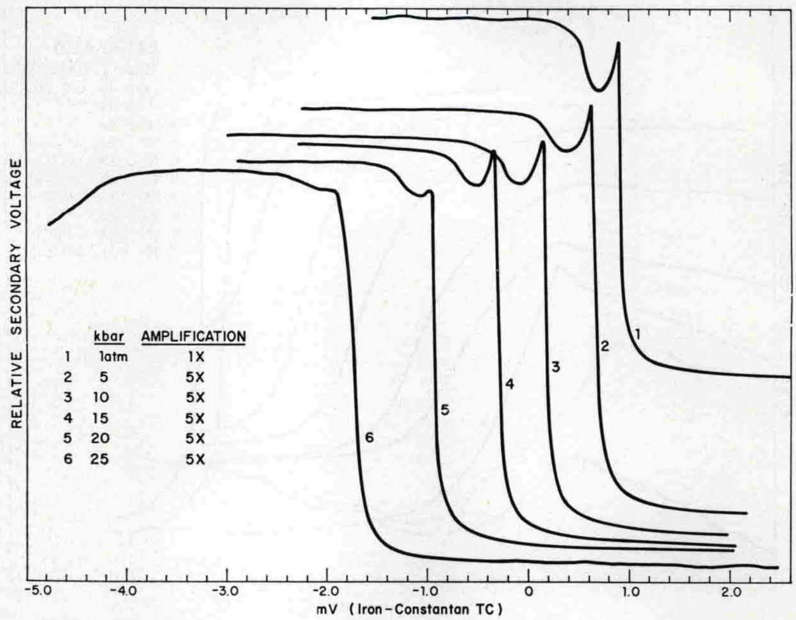

FIG. 4. Relative secondary voltage vs thermocouple output for rings of crystal #10-736. The axis of these washers had no close relationship to the crystallographic axes.

to the results of Fig. 3 for the powder-epoxy ring, which show a new peak starting to appear at this pressure.

A washer was cut from a second crystal, #10-799, with the axis ~10° off the ⟨001⟩ direction. Thus the ⟨100⟩ and ⟨010⟩ directions were in the plane of the ring and covered by windings. Three typical curves obtained on this sample are shown in Fig. 5. The first sharp peak coincides with the T_c at 1 atm as well as the peaks for crystal #10-736 at pressure. The second, much taller, peak is 8–9° below the first at lower pressures and 7° below at 20 and 25 kbar. The temperature of this peak coincides with the small peak observed at 1 atm and 1.25 kbar with the powder-epoxy samples. Pressure suppresses this peak in relation to the first peak. At 25 kbar, the overall shape of the curve may be considered similar to that for the powder-epoxy rings at 30 kbar. Thus the change in shape of the latter between 20 and 35 kbar may be due to an orientation effect enhanced by pressure rather than to a change to antiferromagnetic ordering. However, the change to a positive $\Delta T_c/\Delta P$ above 35 kbar is more likely to be caused by a new magnetic phase.

To find out whether the ⟨010⟩ or ⟨100⟩ direction is responsible for the second peak, a square "picture-frame" was cut from a slice of crystal #10-752 with the face of the slice in the (001) plane. This specimen was wound so that either only the ⟨010⟩ direction or the ⟨100⟩ direction was used. The curves (Fig. 6) clearly show that the ⟨010⟩ direction is responsible for the second peak. Therefore, the double peak observed for crystal #10-799 appears to indicate that the ⟨010⟩ direction was covered by most of the winding.

However, the ingot shape did not make it possible to cut a specimen so that the ⟨001⟩ direction could be included or excluded from the windings. The first peak, which shows up in all single-crystal samples and even in a polycrystalline sample (#TS-2, Fig. 6), may be at least partially due to the inclusion of the ⟨001⟩ direction in the windings. However, the *c* axis is the "easy" magnetic direction (*1*).

Some preferred orientation of the MnP powder particles must occur during dispersion and casting in epoxy cement at room temperature, since some rings show one or more of the peaks observed with the single-crystal rings. This is further demonstrated by the secondary voltage vs thermocouple voltage curves shown in Fig. 7. Ring A, which was wound around its entire circumference, gave a curve with the shape expected for a randomly oriented powder going through ferromagnetic ordering, except for a small peak about 10°K below the T_c. Therefore, the MnP particles had little preferred orientation. However, a second ring, B, was indexed so that it could be wound around a definite part of its circumference. With the first position of the windings, it